ASSEMBLING AND USING YOUR . . . . . Heathkit

OSCILLOSCOPE

MODEL OL-1

595-93

Copyright 1954
Heath Company,
Benton Harbor, Michigan

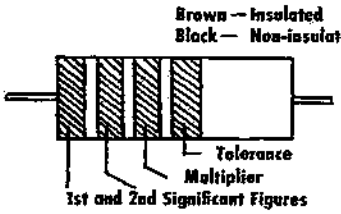
HEATH COMPANY
BENTON HARBOR,
MICHIGAN

PRICE $1.00

STANDARD COLOR CODE — RESISTORS AND CAPACITORS

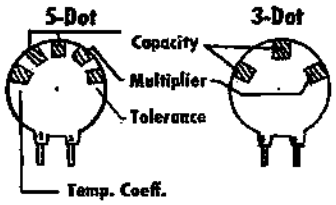
INSULATED UNINSULATED Color	FIRST RING BODY COLOR First Figure	SECOND RING END COLOR Second Figure	THIRD RING DOT COLOR Multiplier
BLACK	0	0	None
BROWN	1	1	0
RED	2	2	00
ORANGE	3	3	,000
YELLOW	4	4	0,000
GREEN	5	5	00,000
BLUE	6	6	000,000
VIOLET	7	7	0,000,000
GRAY	8	8	00,000,000
WHITE	9	9	000,000,000

AXIAL LEAD RESISTOR

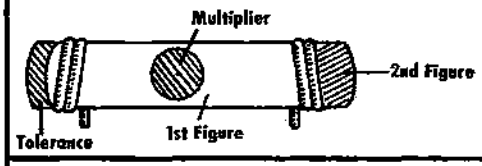


Wire wound resistors have 1st digit band double width

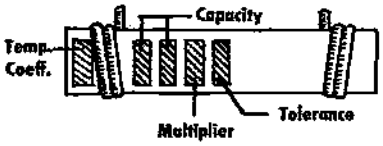
DISC CERAMIC RMA CODE



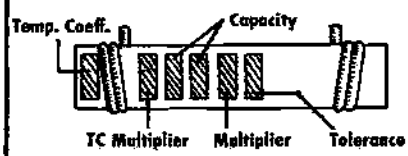
RADIAL LEAD DOT RESISTOR



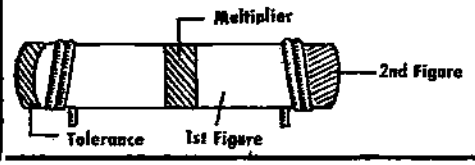
5-DOT RADIAL LEAD CERAMIC CAPACITOR



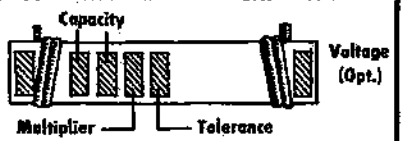
EXTENDED RANGE TC CERAMIC HICAP



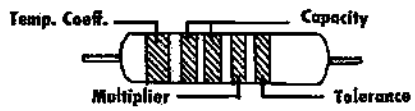
RADIAL LEAD (BAND) RESISTOR



BY-PASS COUPLING CERAMIC CAPACITOR



AXIAL LEAD CERAMIC CAPACITOR

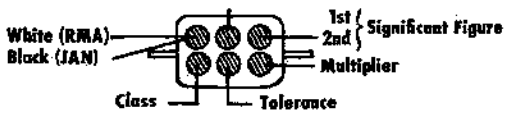


The standard color code provides all necessary information required to properly identify color coded resistors and capacitors. Refer to the color code for numerical values and the zeroes or multipliers assigned to the colors used. A fourth color band on resistors determines tolerance rating as follows: Gold = 5%, silver = 10%. Absence of the fourth band indicates a 20% tolerance rating.

The physical size of carbon resistors is determined by their wattage rating. Carbon resistors most commonly used in Heathkits are ½ watt. Higher wattage rated resistors when specified are progressively larger in physical size. Small wire wound resistors ½ watt, 1 or 2 watt may be color coded but the first band will be double width.

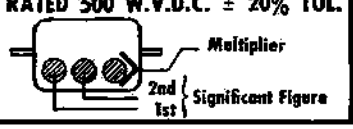
MOLDED MICA TYPE CAPACITORS

CURRENT STANDARD CODE

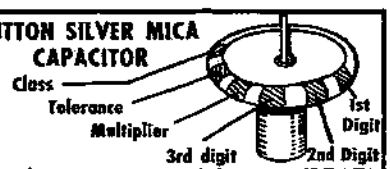


JAN & 1948 RMA CODE

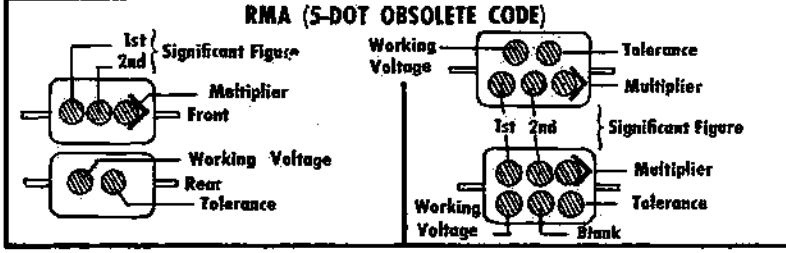
RMA 3-DOT (OBSOLETE) RATED 500 W.V.D.C. ± 20% TOL.



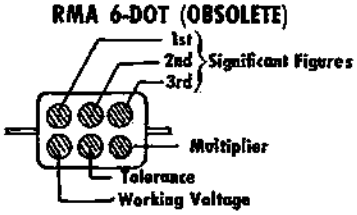
BUTTON SILVER MICA CAPACITOR



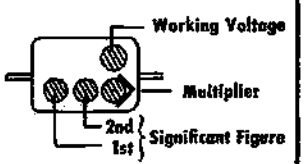
RMA (5-DOT OBSOLETE CODE)



RMA 6-DOT (OBSOLETE)

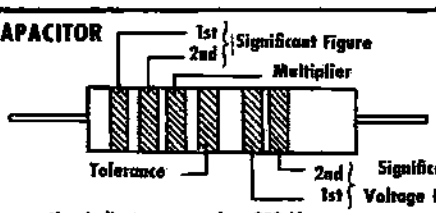


RMA 4-DOT (OBSOLETE)



MOLDED PAPER TYPE CAPACITORS

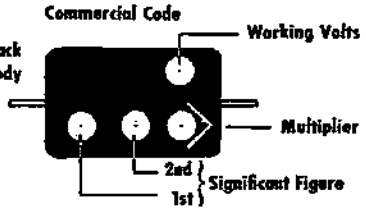
TUBULAR CAPACITOR



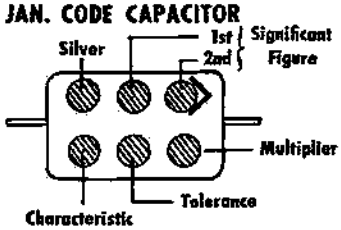
Normally stamped for value

A 2 digit voltage rating indicates more than 900 V. Add 2 zeros to end of 2 digit number.

MOLDED FLAT CAPACITOR



JAN. CODE CAPACITOR



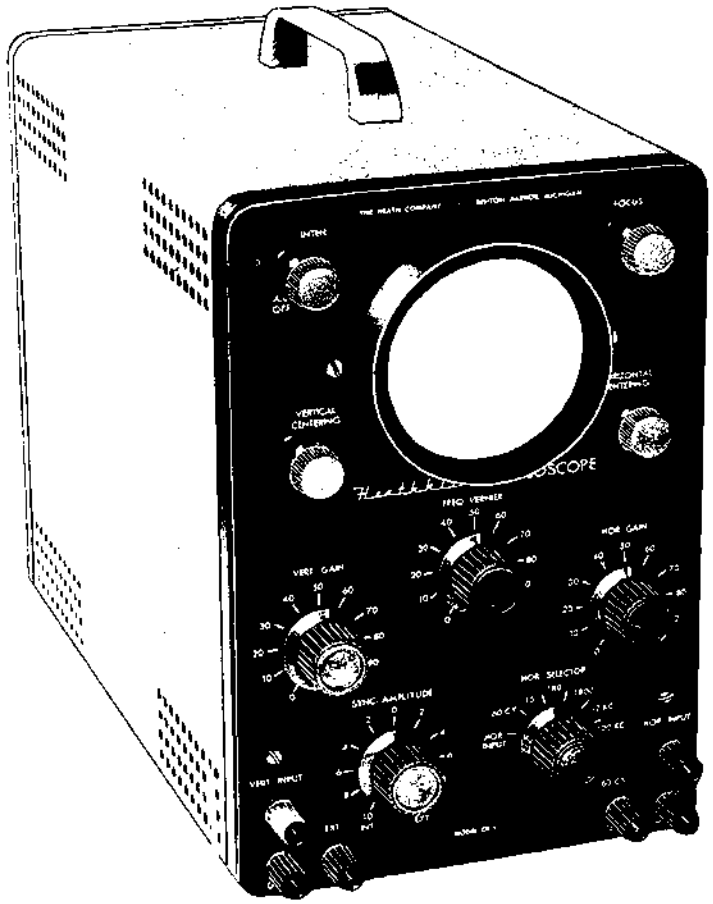
The tolerance rating of capacitors is determined by the color code. For example: red = 2%, green = 5%, etc. The voltage rating of capacitors is obtained by multiplying the color value by 100. For example: orange = 3 × 100 or 300 volts. Blue = 6 × 100 or 600 volts.

In the design of Heathkits, the temperature coefficient of ceramic or mica capacitors is not generally a critical factor and therefore Heathkit manuals avoid reference to temperature coefficient specifications.

Courtesy of Centralab

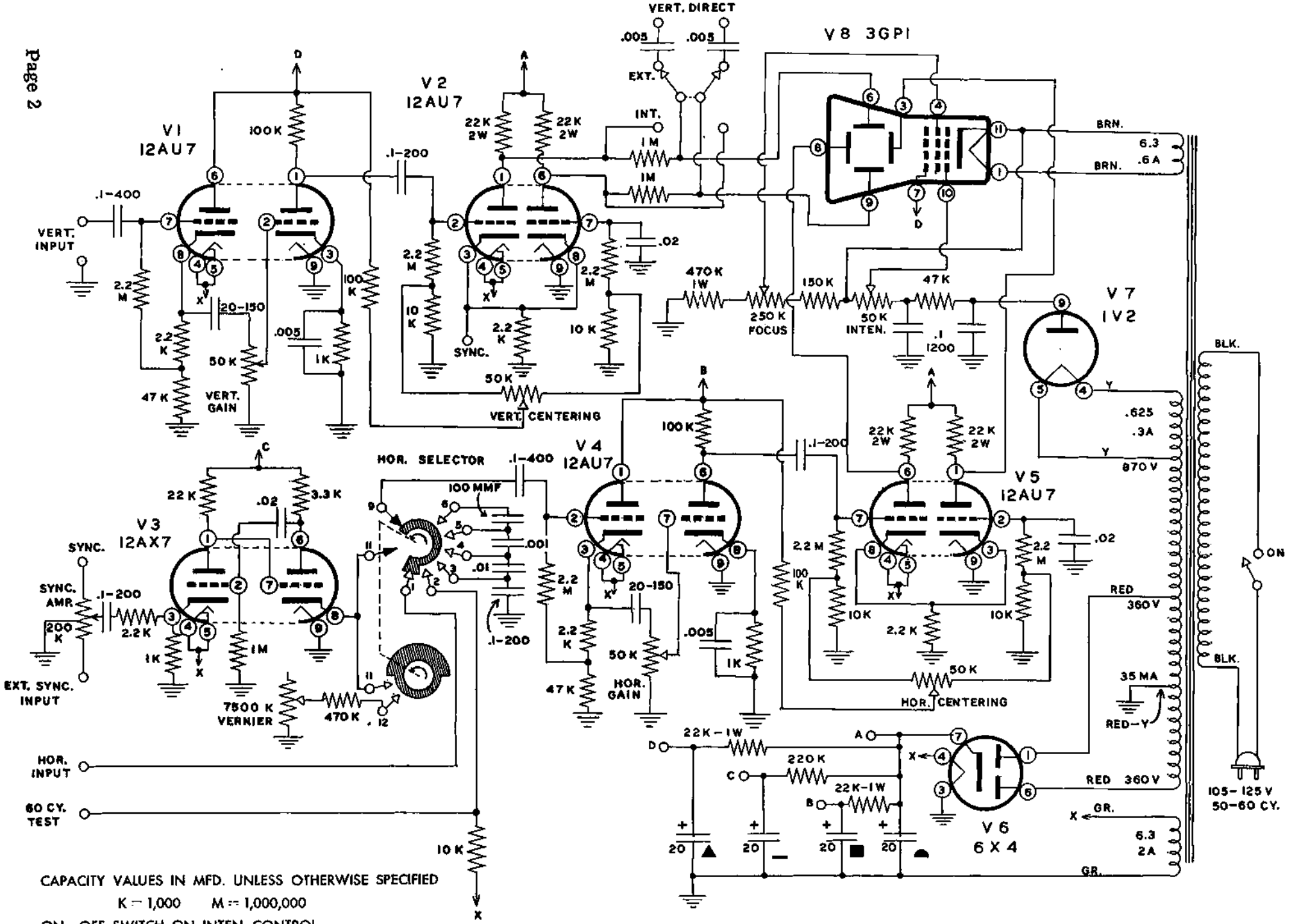
ASSEMBLY AND OPERATION OF THE HEATHKIT OSCILLOSCOPE

MODEL OL-1



SPECIFICATIONS

Vertical:	
Frequency Response	±3 db 2 cps to 200 kc
	±6 db 1 cps to 400 kc
Sensitivity	0.25 volt RMS per inch P-to-P deflection at 1 kc
Input Impedance	20 μμf shunting 10 megohms
Horizontal:	
Frequency Response	±3 db 2 cps to 200 kc
	±6 db 1 cps to 400 kc
Sensitivity	0.3 volts RMS per inch P-to-P deflection at 1 kc
Input Impedance	20 μμf shunting 10 megohms
Sweep Generator	Multivibrator 20-100,000 cps
Tube Complement	1 - 3GP1 Cathode Ray Tube
	2 - 12AU7 Vertical Input - Deflection Amplifier
	2 - 12AU7 Horizontal Input - Deflection Amplifier
	1 - 12AX7 Multivibrator
	1 - 6X4 Low Voltage Rectifier
	1 - 1V2 High Voltage Rectifier
Power Requirements	105-125 volts 50/60 cycles 45 watts
Dimensions	9 1/2" high x 6 1/2" wide x 11 3/4" deep
Net Weight	11 lbs.
Shipping Weight	15 lbs.



HEATHKIT OSCILLOSCOPE MODEL OL-1

INTRODUCTION

The cathode ray oscilloscope is without a doubt the most versatile electronic instrument available today. Basically, it is an indicating device which can display in usable form, the actual voltage variations in an electrical quantity as compared to time. This however, is merely its basic function and it would be impossible at this time to enumerate all of its qualifications. It is the type of instrument for which the operator can continue to find new applications even after many years of use.

Some of the many desirable features are as follows:

1. It displays instantly information that otherwise would require hours of experimentation.
2. Wave forms can easily be photographed and retained for future reference.
3. It usually has a negligible effect on the characteristics of a circuit under test.
4. It has an extremely wide range of sensitivity.
5. It is rugged, dependable and not easily damaged by overload or surges.

CONSTRUCTION HINTS

The construction of the Heathkit model OL-1 Oscilloscope has been simplified tremendously by the use of an etched circuit board. The major portion of the complete oscilloscope circuit is already wired except for the addition of sockets and the placement of resistors and condensers. This extremely new development in the kit instrument field represents countless advantages for the kit builder. It practically assures him of optimum performance by eliminating the factors that previously caused the lack of uniformity between individual kits.

No longer must you worry about long or improperly dressed leads in critical parts of the circuit. The possibility of poor performance due to wiring errors has been reduced to a bare minimum. Component values are indicated directly on the circuit board itself, thus eliminating the need for page after page of tedious instructions. Perhaps the principal advantages are in the fact that construction time is substantially reduced and that each completed kit will be equal in every respect to the carefully prepared sample models built up in the Heathkit engineering laboratories.

Printed circuits in themselves are not entirely new, but their use in a kit instrument is definitely an innovation. There are a number of methods by which the circuit board is manufactured, but basically it is merely an insulating material upon which a metal conductor pattern is impressed. The pattern is usually applied to a copper plated board made of a laminated phenolic material by photography or one of the many printing processes. The excess copper is then etched away leaving only the desired pattern. Some methods include the application of a silver coating to facilitate soldering and conductivity. Finally the holes are drilled or punched for the proper mounting of parts.

When soldering to the copper circuit pattern, discretion should be used in order that the board will not be damaged by excessive heat. The actual technique is not at all difficult, but the soldering iron itself is an important factor. The tip should be small such as those used in soldering pencils and the rating of the iron should not exceed 50 watts. Very little solder is required and it must be of the rosin core variety. A "tin versus lead" content of 60-40 or 40-60 is acceptable. Acid and paste fluxes will damage the board beyond repair. It is recommended that the soldering instructions at the point in the manual where the soldering of the board is begun be read very carefully. For the other connections in the kit, the notes on the inside of the rear cover will be more than sufficient.

The Heathkit model OL-1 Oscilloscope, when properly constructed will provide years of satisfactory service. We therefore urge you to take all the time that is necessary to do a good job. Do not hurry the work and you will be rewarded with a greater sense of confidence both in the equipment and in your own workmanship.

This manual is supplied to assist you in every way to complete the instrument with the least possible chance of error. We suggest that you take a few minutes now and read the manual through before work is started. This will enable you to proceed with more certainty when construction is begun. The large fold-in pictorials can be attached to the wall above your work bench for ready reference. They are repeated in smaller form within the manual. The manual itself should be retained for the future use and maintenance of the instrument.

UNPACK THE KIT CAREFULLY AND CHECK EACH PART AGAINST THE PARTS LIST. In so doing, you will become acquainted with each part. Refer to the charts and other information shown on the inside covers of the manual to help you identify any part about which there may be a question. If some shortage is found in checking the parts, please notify us promptly and return the inspection slip with your letter to us. Hardware items are counted by weight and if a few are missing, please obtain them locally if at all possible.

Use only the best rosin core solder, preferably one containing the new activated fluxes, such as Kester "Resin-Five," Ersin "Multicore" or similar types.

Resistors and controls generally have a tolerance rating of ±20% unless otherwise stated in the parts list. Therefore a 100 KΩ resistor may test anywhere from 80 KΩ to 120 KΩ. (The letter K is commonly used to designate a multiplier of 1000.) Tolerances on condensers are generally even greater. Limits of +100% and -50% are common for electrolytic condensers. The parts furnished with your Heathkit have been specified so as to not adversely affect the operation of the finished instrument.

In order to expedite delivery to you, we are occasionally forced to make minor substitution of parts. Such substitutions are carefully checked before they are approved and the parts supplied will work satisfactorily. By checking the parts list for resistors, for example, you might find that a 2.2 megohm resistor has been supplied in place of a 2 megohm resistor as shown in the parts list. These changes are self-evident and are mentioned here only to prevent confusion to you in checking the contents of your kit.

We strongly urge that you follow the wiring and parts layout shown in the manual. Although most of the critical connections are etched into the circuit board, some of the others may affect the characteristics of the instrument if their positions are radically changed from the layout as described in this manual.

STEP-BY-STEP ASSEMBLY AND WIRING

A space is provided in front of each step so that you can check off each operation as it is completed. This method will prevent confusion if your work is interrupted.

SECTION 1

(√) Lay the chassis flat on your work surface with the large rectangular cut-out toward you and the chassis skirts upward. See Pictorial 1.

(√) Install banana jack inserts into each of the two red banana jacks as shown. Pull them through with a pair of pliers and crimp them to prevent pulling out.

( ) Now install both banana jack assemblies in the large chassis skirt, using speed nuts.

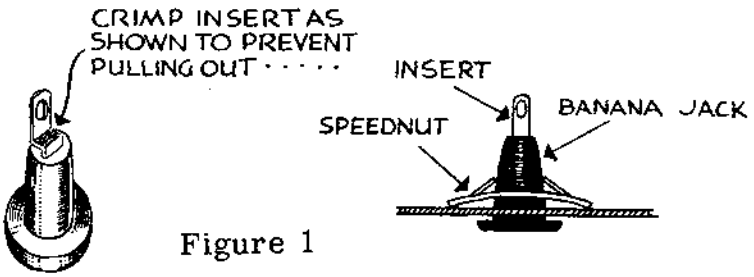
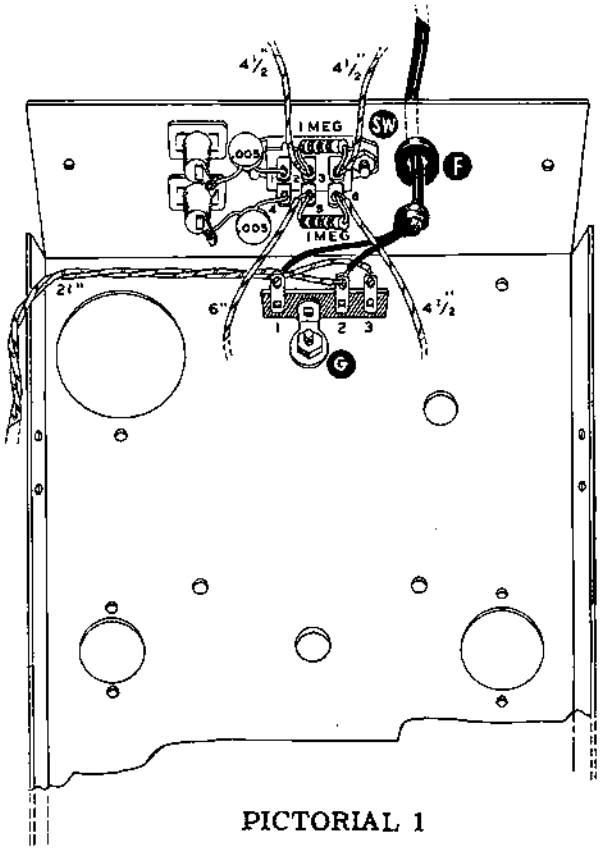


Figure 1

(√) Mount the DPDT slide switch SW as shown, using 6-32 x 3/8" screws, #6 lockwashers and 6-32 nuts.

(√) Install a 3/8" rubber grommet in the hole at F.

(√) Install a 3-lug terminal strip at G. Use 6-32 hardware.



PICTORIAL 1

NOTE: ALL GUARANTEES ARE VOIDED AND WE WILL NOT REPAIR OR SERVICE INSTRUMENTS IN WHICH ACID CORE SOLDER OR PASTE FLUXES HAVE BEEN USED. WHEN IN DOUBT ABOUT SOLDER, IT IS RECOMMENDED THAT A NEW ROLL PLAINLY MARKED "ROSIN CORE RADIO SOLDER" BE PURCHASED.

(NS) means do not solder yet because other wires are to be connected to this terminal later.
(S) means solder the terminal, making sure that all wires connected to that point are included.

All wire referred to is insulated hookup wire unless otherwise specified. Each end should be stripped of insulation back about 1/4". Be sure to trim resistor and condenser leads to the lengths required for each individual connection.

( ) Connect a .005 μfd disc ceramic condenser from lug 1 (S) of switch SW to the adjacent banana jack lug (S).

( ) Connect another .005 μfd disc ceramic condenser from lug 4 (S) of SW to the other banana jack (S).

( ) Connect a 1 megohm resistor (brown-black-green) from lug 5 (NS) to lug 6 (NS) of switch SW.

( ) Wire another 1 megohm resistor from lug 2 (NS) to lug 3 (NS) of switch SW.

( ) Connect one end of a 6" length of wire to lug 5 (S) of switch SW. Leave the other end free.

( ) Connect one end of a 4 1/2" length of wire to lug 2 (S) of switch SW. Leave the other end free.

( ) Connect one end of a 4 1/2" length of wire to lug 6 (S) of switch SW. Leave the other end free.

( ) Connect one end of a 4 1/2" length of wire to lug 3 (S) of switch SW. Leave the other end free.

( ) Cut two pieces of wire to a length of 23" each. Twist these wires together to form a twisted pair about 21" to 22" long. At one end, connect either of the leads to lug 2 (NS) of terminal strip G and the other to lug 3 (NS) of the same strip. The free ends can be left hanging for the time being.

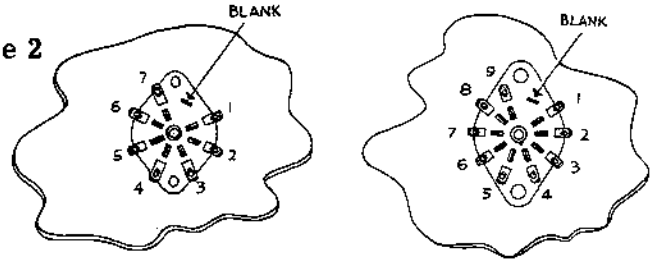
( ) Tin the bare copper wires at the stripped ends of the line cord. This can be done by heating the copper strands with a hot soldering iron and then flowing solder on the ends until it spreads freely.

( ) Pass the line cord into the chassis through the hole at F. Tie a knot in the cord about 2 1/2" from the end so that it cannot be pulled out again. Connect either of the leads to lug 2 (S) of terminal strip G. Connect the other lead to lug 1 (NS) of the same strip.

( ) Now turn the chassis over as in Pictorial 2 with the large rectangular cut-out toward you and the chassis skirts downward.

( ) Inspect both of the wafer type miniature sockets. Be sure that the blank space in the bottom wafer of each socket corresponds in location with the blank space in the top wafer.

Figure 2



NUMBERING ON 7-PIN TUBE SOCKET NUMBERING ON 9-PIN TUBE SOCKET

( ) Install the 9-pin socket at V7 with the blank space upward. Be sure that the flat side lies against the chassis so that the metal pins do not extend through the mounting holes. Use 3-48 x 1/4" screws and 3-48 nuts.

( ) In like manner, install the 7-pin socket at V6.

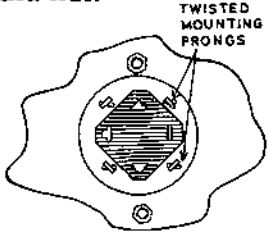
( ) Install the metal condenser mounting wafer from the under side of the chassis at A. Use 6-32 x 3/8" screws with a #6 lockwasher under the top 6-32 nut and a #6 solder lug under bottom nut.

( ) Mount a 2-lug terminal strip at B just above the 9-pin socket. Use a 6-32 x 3/8" screw, #6 lockwasher and 6-32 nut.

( ) Install a #6 solder lug as shown at C. Use a 6-32 x 3/8" screw and nut.

( ) Observe closely the identification marks (▬ ▲ ■ ▰) for each of the four inner lugs on the large metal filter condenser, 25-21. Install the condenser from the under side of the chassis at A. The ▲ marked lug should be nearest the top as in Pictorial 2. While holding the condenser firmly in place, twist each of the four mounting lugs about 1/8 to 1/4 turn. The twisted wires attached to terminal strip G can now be temporarily wrapped around the filter condenser can to keep them out of the way.

Figure 3



CONDENSER LUG MARKINGS

( ) Now install 3/8" rubber grommets in the holes at D and E.

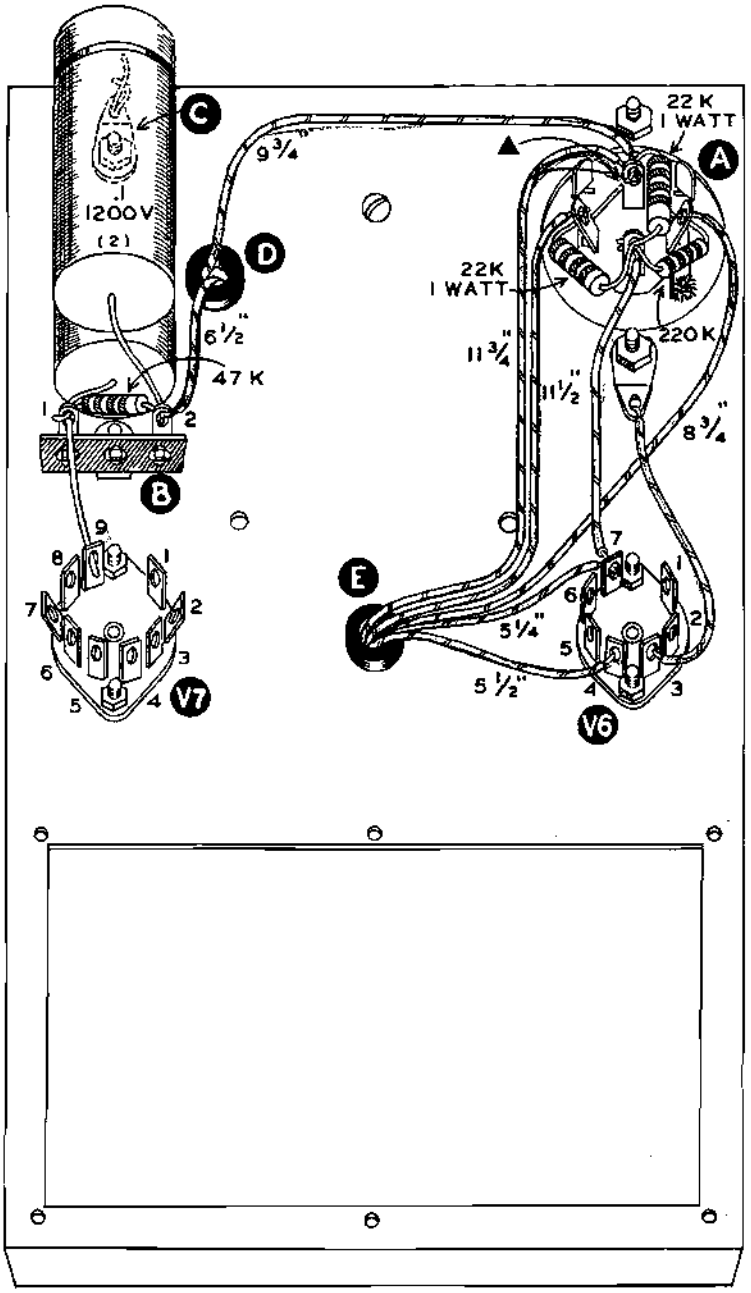
( ) To make sure of a good ground connection for the low voltage filter condenser A, solder one of the twisted mounting lugs to the metal mounting wafer.

( ) Connect a wire from pin 3 (NS) of the 6X4 low voltage rectifier tube socket V6 to the solder lug (NS) located below the filter condenser A.

( ) Connect a wire from pin 7 (NS) of the low voltage rectifier socket V6 to the filter condenser A, lug ▰ (NS).

( ) Cut an 8 3/4" length of wire and connect one end to lug ▬ (NS) of filter condenser A. Insert the other end into hole E. Dress as shown.

PICTORIAL 2



(L) Cut a 5 1/4" length of wire and connect one end to pin 7 (S) of socket V6. Insert the other end into hole E.

(L) Cut an 11 1/2" length of wire and connect one end to lug ■ (NS) of filter condenser A. Insert the other end into hole E.

( ) Cut an 11 3/4" length of wire and connect one end to lug ▲ (NS) of filter condenser A. Insert the other end into hole E.

(A) Cut a 5 1/2" length of wire and connect one end to pin 4 (NS) of V6. Insert the other end into hole E.

NOTE: The five wires which are now inserted into hole E can be temporarily taped to the under side of the chassis.

(✓) Cut a 9 3/4" length of wire and connect one end to lug ▲ (NS) of filter condenser A. Dress the lead as shown and insert the other end into hole D.

(✓) Cut a 6 1/2" length of wire and connect one end to lug 2 (NS) of terminal strip B. Insert the other end into hole D. The two wires through hole D can now be taped to the under side of the chassis.

(✓) Connect a 220 KΩ resistor (red-red-yellow) from lug ▲ (NS) of filter condenser A to lug ▬ (S).

NOTE: There are three different sizes of 22 KΩ resistors in this kit. They are all color coded (red-red-orange). The 1/2 watt size is the smallest and the 1 watt size is next. The 2 watt size is largest. It is very important that the proper size is used in each case.

( ) Connect a 22 KΩ 1 watt resistor (red-red-orange) from lug ▲ (NS) of filter condenser A to lug ▲ (S).

( ) Connect another 22 KΩ 1 watt resistor (red-red-orange) from lug ▲ (S) of filter condenser A to lug ■ (S).

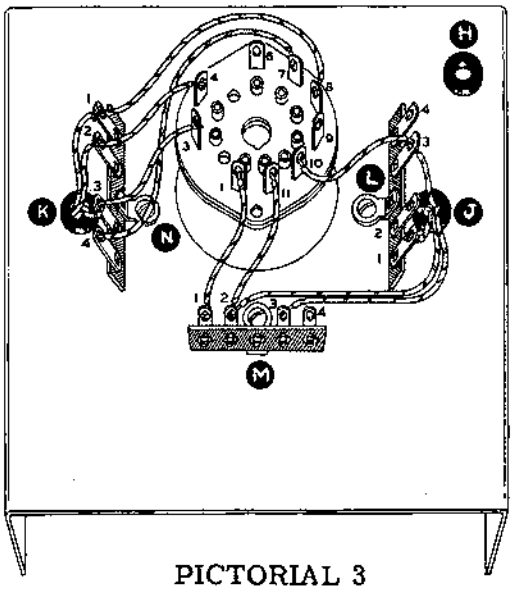
(✓) Connect a 47 KΩ resistor (yellow-violet-orange) from lug 1 (NS) of terminal strip B to lug 2 (NS) of the same strip.

NOTE: There are three different varieties of .1 μfd condensers. The very largest paper tubular type is rated at 1200 volts DC. The next largest size is rated 400 volts DC. The smallest of the .1 μfd condensers is rated at 200 volts DC. These voltage ratings are printed on the condenser in each case and it is important that the proper rating is used in each of their respective positions.

( ) Place a .1 μfd 1200 volt DC condenser as shown between terminal strip B and solder lug C. The outside foil end (dark colored band) should be toward C. Run one condenser lead through lug 1 of terminal strip B to pin 9 of the 1V2 high voltage rectifier tube socket V7. Now solder B1 and V7-9. Connect the other condenser lead to solder lug C (NS).

( ) Place another .1 μfd 1200 volt DC condenser directly on top of the other with the outside foil end again toward the solder lug C. Connect one lead to C (S) and the other to lug 2 (S) of terminal strip B.

SECTION 2



PICTORIAL 3

( ) Position the CRT support bracket as in Pictorial 3 with the large circular opening toward the top and the skirts downward.

( ) Insert 3/8" rubber grommets in holes H, J and K.

( ) Mount a 4-lug terminal strip at M using 6-32 hardware.

( ) Mount another 4-lug terminal strip at N, but this time install one of the small angle brackets under the lockwasher as shown in Figure 4.

( ) Refer again to Figure 4 and install another 4-lug terminal strip and angle bracket at L.

( ) Cut an 8 1/2" piece of wire and connect one end to lug 1 (NS) of terminal strip L. Insert the other end into hole J.

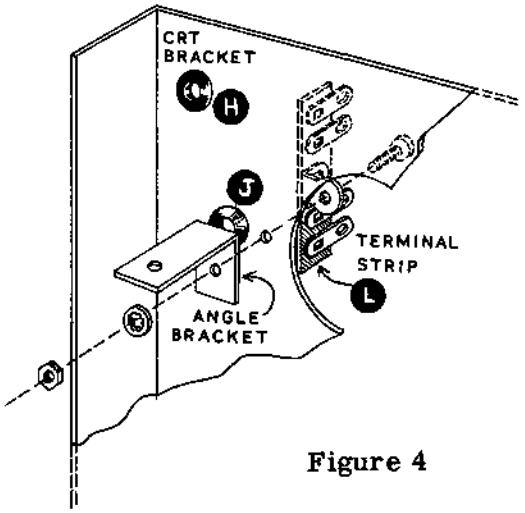


Figure 4

( ) Cut a 7 1/2" piece of wire and connect one end to lug 2 (NS) of terminal strip L. Insert the other end into hole J.

( ) Cut a 10 1/2" length of wire and connect one end to lug 3 (NS) of terminal strip L. Insert the other end into hole J.

( ) Cut a 3 1/2" piece of wire and connect one end to lug 3 (S) of terminal strip L. The other end is then connected to pin 10 (S) of the 11 pin cathode ray tube (CRT) socket. Since the CRT socket is not yet mounted to any of the stationary parts of the oscilloscope, it will be hanging by one lead. You will find however, that as more connections to the socket are made, the leads themselves will provide adequate support. The socket pins are numbered from 1 to 11 counting counterclockwise when viewing the socket from the rear. Lug 4 of terminal strip L is not used.

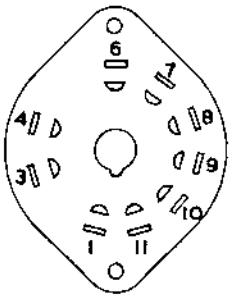


Figure 5

NUMBERING OF 11- PIN CRT SOCKET

( ) Cut a 13" length of wire and connect one end to lug 3 (NS) of terminal strip M. Dress as shown and insert the other end into hole J.

( ) Cut a 14" length of wire and connect one end to lug 2 (NS) of terminal strip M. Dress and insert the other end into hole J. There should now be five long wires through hole J.

( ) Cut a 3" piece of wire and connect it from lug 2 (NS) of terminal strip M to pin 11 (S) of the CRT socket.

( ) Cut another 3" piece of wire and connect it from lug 1 (NS) of terminal strip M to pin 1 (S) of the CRT socket. Lug M4 is not used.

( ) Connect a 6" piece of wire from lug 4 (NS) of terminal strip N to pin 7 (S) of the CRT socket.

( ) Connect a 3" piece of wire from lug 3 (NS) of terminal strip N to pin 3 (S) of the CRT socket.

( ) Connect a 3" piece of wire from lug 2 (NS) of terminal strip N to pin 4 (S) of the CRT socket.

( ) Connect a 5 1/2" piece of wire from lug 1 (NS) of terminal strip N to pin 8 (S) of CRT socket.

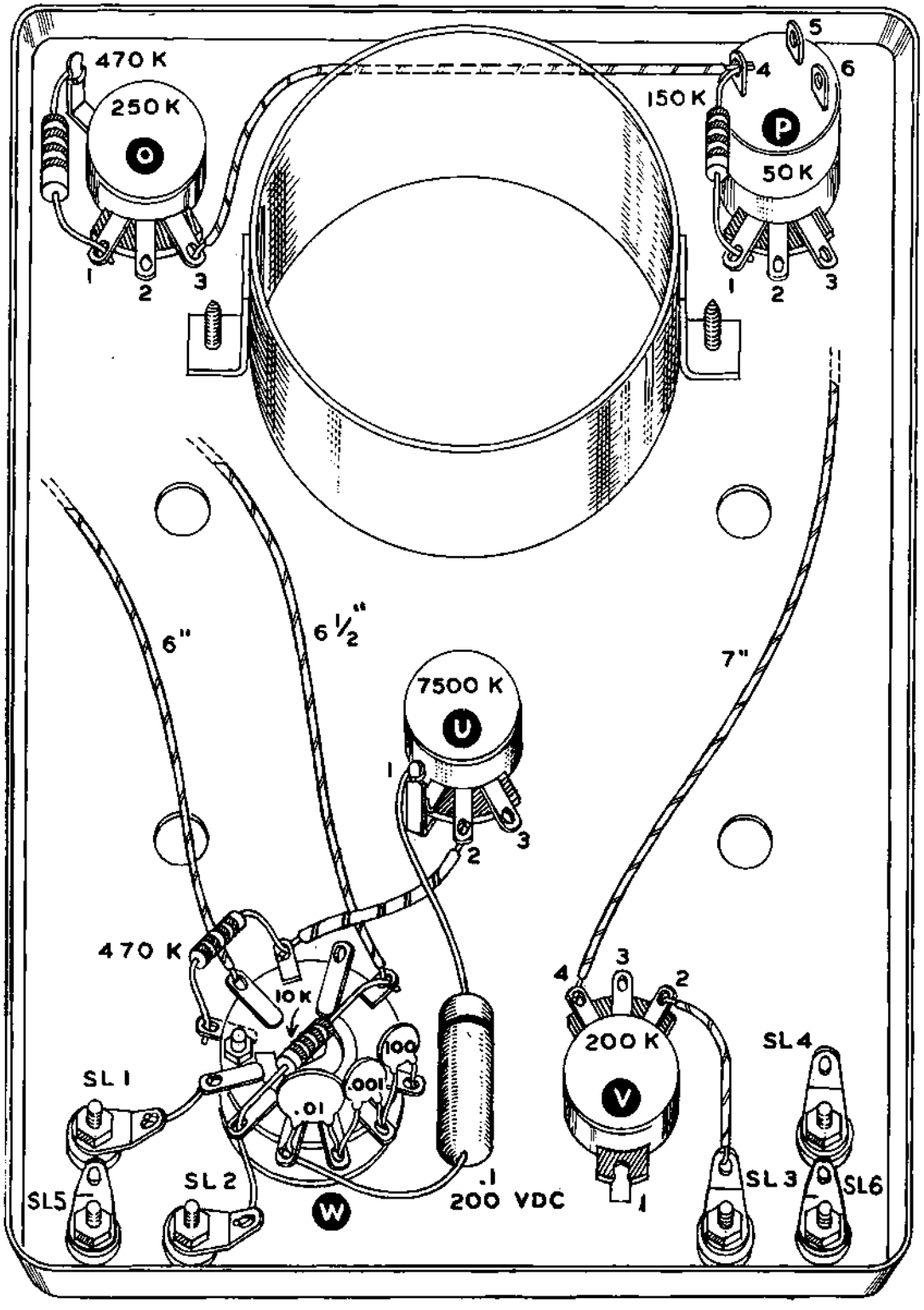
( ) Connect an 8" length of wire to lug 1 (S) of terminal strip N. Insert the other end through hole K.

( ) Connect a 10 1/4" length of wire to lug 2 (S) of terminal strip N. Insert the other end through hole K.

( ) Connect a 7" length of wire to lug 3 (S) of terminal strip N. Insert the other end through hole K. There should now be three long wires through hole K.

SECTION 3

PICTORIAL 4



Be sure to flatten out any locating pin on the controls that might interfere with their installation on the panel.

( ) Slip a control solder lug over the shaft of the 250 KΩ **FOCUS** control. Install the control at position O on the front panel as shown in Pictorial 4. Bend the solder lug away from the panel edge to prevent interference when the cabinet is installed. Tighten down with a control flat washer and control nut.

( ) Install the 50 KΩ **INTENSITY** control with SPST switch and dummy lug at P. Use a control lockwasher over the shaft and tighten down with a flat washer and nut. Position the lugs as shown.

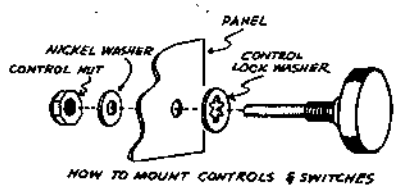


Figure 6

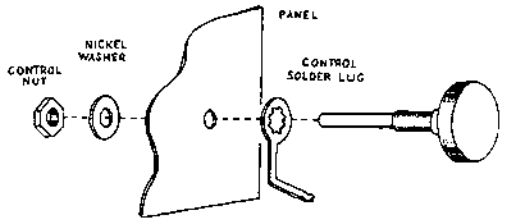
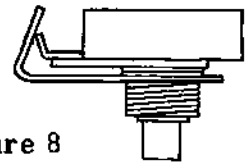


Figure 7

( ) Slip a control solder lug over the shaft of the 7500 KΩ **FREQ. VERNIER** control as shown. Carefully bend back the solder lug until it contacts lug 1 of the control. Now solder these two lugs together firmly. If difficulty is encountered, the solder lug can be temporarily held in position by means of a control nut. Be sure to handle the lugs of the control carefully and to remove the control nut before the control is mounted to the panel.

( ) Now install the **FREQ. VERNIER** control at U. Use a control flat washer and nut.

( ) Prepare the 200 KΩ center tapped **SYNC. AMPLITUDE** control in the same manner. This time the control solder lug should be soldered to the single lug which is isolated from the other three.

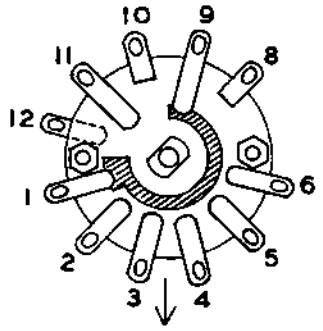


CONTROL WITH SOLDER LUG ASSEMBLED

Figure 8

( ) Install the control at position V as shown.

( ) Carefully inspect the 6-position rotary switch 63-83 and notice that there are six short contacts and two long ones. Mount the switch at W with the side having the six short contacts next to the bottom of the panel. Use a control lockwasher, flat washer and nut.



HOR. SELECTOR SWITCH

Figure 9

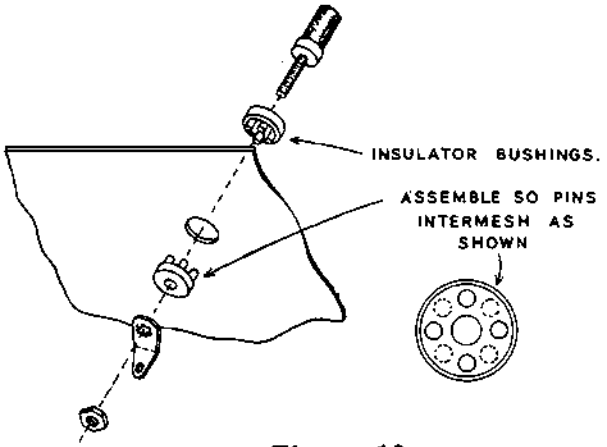


Figure 10

( ) Install binding post bases in each of the six holes at the bottom of the panel. Use special insulator bushings and add a #6 solder lug under the nut at each position. Refer to Pictorial 4 and orient the solder lugs as shown.

( ) Install the CRT ring in the large panel opening as shown. The seam should be toward the bottom of the panel and the ring is secured in place by means of two #6 x 3/8" sheet metal screws.

( ) Connect a 470 KΩ 1 watt resistor (yellow-violet-yellow) from lug 1 (S) of control O to the solder lug (S) which is installed under the control.

( ) Connect a wire from lug 3 (S) of control O to lug 4 (NS) of control P.

( ) Connect a 150 KΩ resistor (brown-green-yellow) from lug 1 (NS) of control P to lug 4 (S) of the same control.

( ) Connect the outside foil lead of a .1 μfd 200 volt DC condenser to the solder lug (S) which is soldered to lug 1 of control U. Wire the other condenser lead to lug 3 (NS) of switch W.

( ) Connect a wire from lug 2 (S) of control U to lug 10 (NS) of switch W.

( ) Connect a 6" length of wire to lug 11 (S) of the switch W. Notice that this is a double lug which connects to both the front and back of the switch wafer. Leave the other end free.

( ) Wire a 470 KΩ resistor (yellow-violet-yellow) from lug 12 (S) to lug 10 (S) of switch W.

( ) Run one lead of a 10 KΩ resistor (brown-black-orange) through lug 2 (NS) of switch W to solder lug SL2 (S). Now solder W2. Connect the other resistor lead to lug 8 (NS) of the switch.

( ) Connect a 6 1/2" length of wire to lug 8 (S) of switch W. Leave the other end free.

( ) Connect a 100 μμf disc ceramic condenser from lug 6 (S) to lug 5 (NS) of switch W.

( ) Connect a .001 μfd disc ceramic condenser from lug 5 (S) to lug 4 (NS) of switch W.

( ) Connect a .01 μfd disc ceramic condenser from lug 4 (S) to lug 3 (S) of switch W.

( ) Connect a short wire from lug 1 (S) of switch W to the solder lug SL1 (S). Insulation is not required for this wire. You can use bare wire that has been clipped from a resistor or a condenser lead.

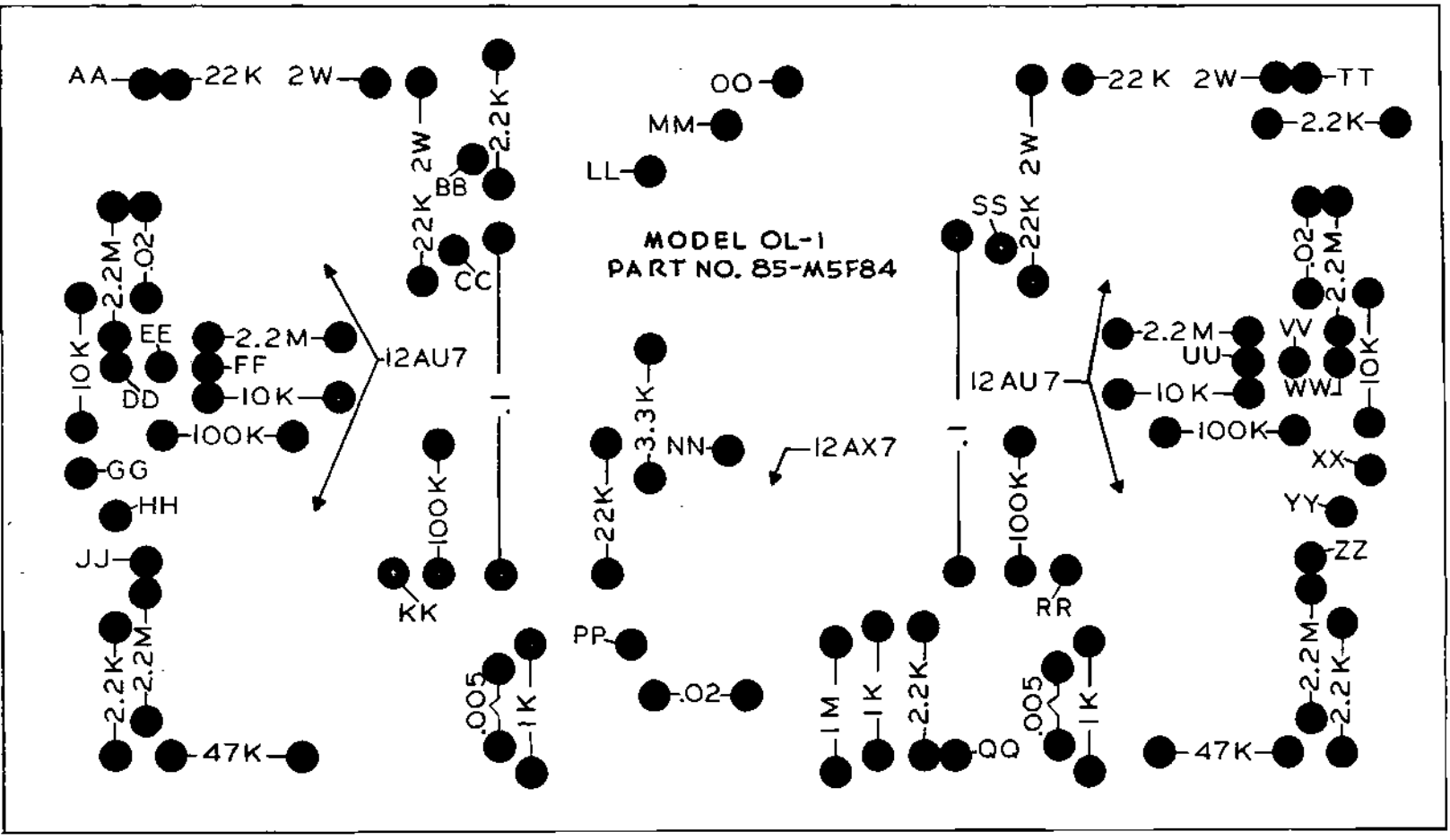
( ) Connect a wire from lug 2 (S) of control V to the solder lug SL3 (S).

( ) Connect one end of a 7" length of wire to lug 4 (S) of control V. Leave the other end free.

The four remaining controls will be installed and wired later when the panel is mounted to the chassis.

SECTION 4

To anyone experienced in the mounting and soldering of parts to an etched circuit board, the information on the board itself will be self-explanatory. If however, this is your first experience with the circuit board, you will probably find the following sequence of construction to be most logical and practical. Soldering should be done with a small tip and preferably with an iron rated at 25 watts to 50 watts. If a soldering gun is used, do not touch the tip to the circuit until it is hot enough to solder immediately. The tip should be held against the circuit only long enough to cause the solder to flow freely and make a good electrical bond. Above all, do not use acid or paste fluxes.



PICTORIAL 5 605-84

( ) Lay the circuit board before you as shown in Pictorial 5 so that the component values are visible. Select the twenty-seven 1/2 watt resistors (smallest size) that are used on the board and bend each lead to a right angle with respect to the resistor body. Make the bend as close as possible to the body of the resistor.

The values are as follows:

3 - 1 KΩ (brown-black-red)
5 - 2.2 KΩ (red-red-red)
1 - 3.3 KΩ (orange-orange-red)
4 - 10 KΩ (brown-black-orange)
1 - 22 KΩ (red-red-orange)
2 - 47 KΩ (yellow-violet-orange)
4 - 100 KΩ (brown-black-yellow)
1 - 1 Meg. (brown-black-green)
6 - 2.2 Meg. (red-red-green)

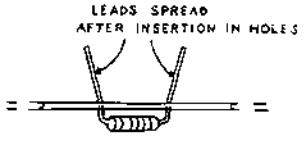
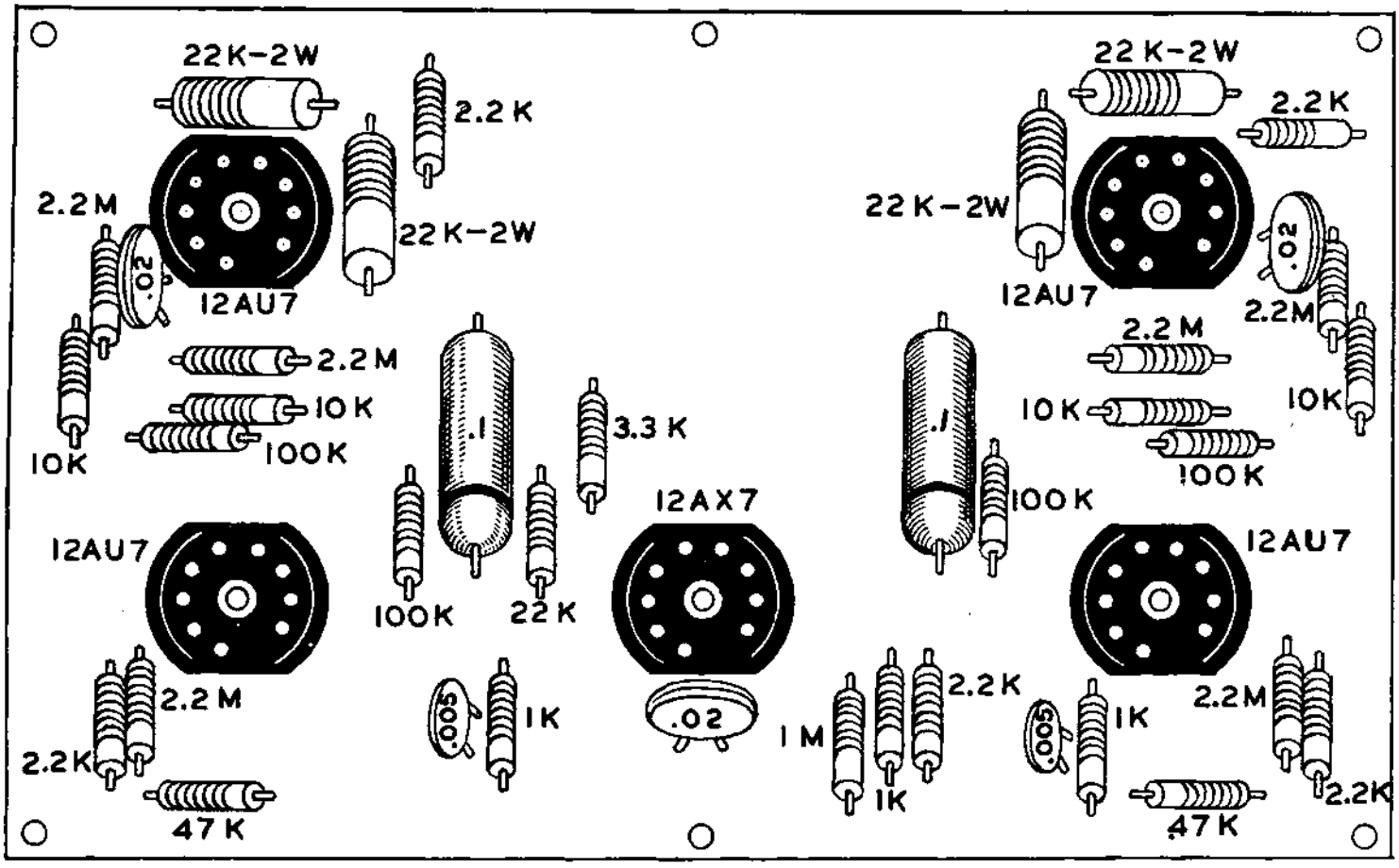


Figure 11

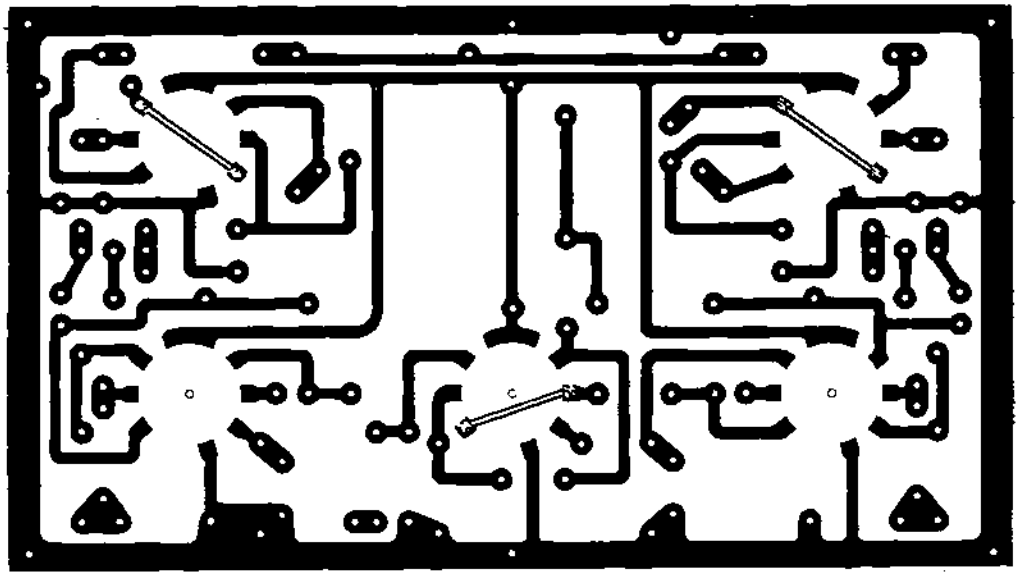
( ) Insert each resistor lead into the proper hole using as a reference the values printed on the board itself. The body of each resistor should be pressed firmly against the board.

( ) After all 1/2 watt resistors are mounted, turn the board over and press firmly against a flat surface. This will hold the resistors in place. Begin soldering at either end of the board where the resistor leads are easily reached with the iron. Hold the tip of the iron in contact with both the lead and the metal surrounding the hole through which the lead protrudes. Flow on a small amount of rosin core solder and remove the iron as soon as the solder begins to spread freely around the hole. Be careful not to fill up any adjacent hole with solder.

( ) Solder as many connections as can be reached easily. Then clip off each soldered lead about 1/8" from the board. Solder a few more leads and then clip them off in the same manner. By following this procedure, you will soon have all twenty-seven resistors firmly soldered in place.



PICTORIAL 6



PICTORIAL 7

( ) Turn the circuit board over again as in Pictorial 5 and install the five remaining 9-pin sockets. The socket pins should extend through the holes so that the socket itself rests on the board on the same side as the resistors.

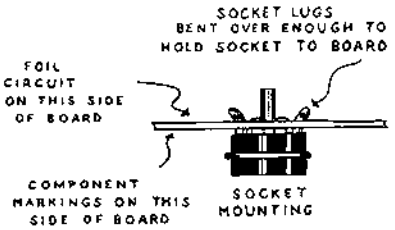

SOCKET LUGS BENT OVER ENOUGH TO HOLD SOCKET TO BOARD
FOIL CIRCUIT ON THIS SIDE OF BOARD
COMPONENT MARKINGS ON THIS SIDE OF BOARD
SOCKET MOUNTING

Figure 12

( ) Rotate each socket until the blank spaces in the sockets and the circuit patterns all coincide. Bend each socket pin over as shown, except those that require bare jumper wires. This will hold each socket in place until the pins are soldered.

( ) Using the same soldering technique, solder each pin to the metal circuit, except pins 1 and 7 of the 12AX7 socket and pins 3 and 8 of the other two sockets that require bare wire connections. See Pictorial 7.

( ) Using bare wire clipped from the previously mounted resistors, cut three pieces about 3/4" in length. Slide them through pins 3 and 8 of two sockets as shown in Pictorial 7 and through pins 1 and 7 of the 12AX7 socket. Solder the wires and the pins to the circuit.

( ) Install and solder the four 22 KΩ 2 watt resistors (red-red-orange).

( ) Install and solder the two .1 μfd 200 volt DC tubular condensers. Refer to the pictorial for proper positioning of the outside foil leads.

( ) Install and solder the three .02 μfd disc ceramic condensers.

(✓) Install and solder the two .005 μfd disc ceramic condensers.

SECTION 5

(✓) Refer to Pictorial 8 and install the circuit board in the following manner:

Insert six 3-48 screws into the same side of the board on which the parts are mounted. On the other side, slip #3 lockwashers over each of the screws. Now mount the board to inside surface of the chassis and tighten down with 3-48 nuts. It is very important that the lockwasher be located between the chassis and the metal surface of the circuit board. Inspect the assembly and make sure that there is no contact between the chassis and the copper foil of the circuit board except along the border where the mounting holes are punched.

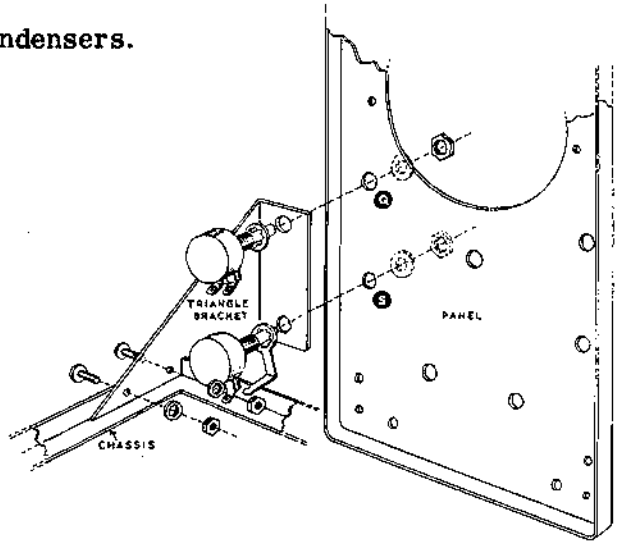


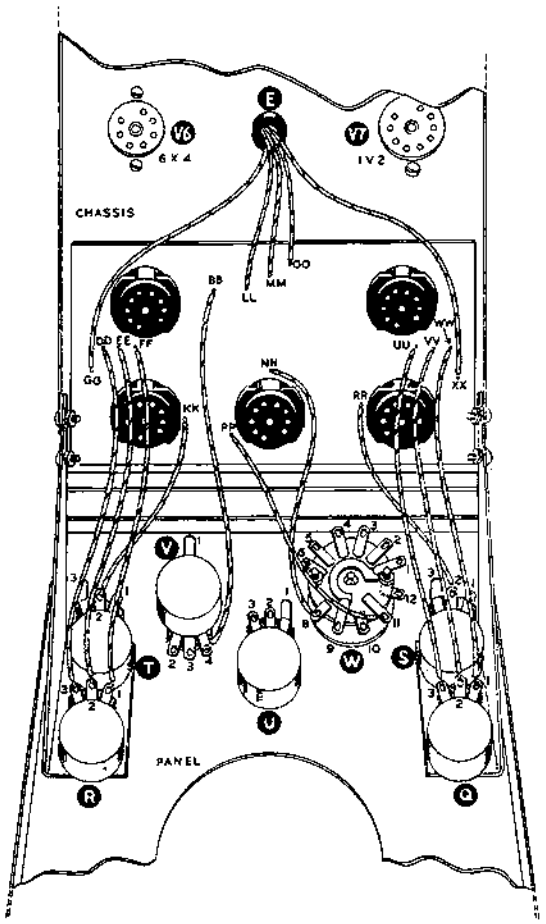
Figure 13

( ) Now install the 50 KΩ HORIZONTAL CENTERING control at position Q on the front panel. The control shaft is inserted through the right-hand triangular panel bracket as shown. Use a control lockwasher, flat washer and nut.

CAUTION: Be very careful to avoid injury during the next few construction steps. The pointed ends of each panel bracket can cause serious injury if you bend over too closely to the panel while installing the remaining controls.

(✓) Install the 50 KΩ VERTICAL CENTERING control through the left-hand bracket and the panel at position R.

PICTORIAL 8



To clarify this and other drawings many of the parts previously mounted and wired have been omitted.

( ) Slip a control solder lug over the shaft of the 50 KΩ HOR. GAIN control and solder it to lug 3. Install it at S on the front panel using a control flat washer and nut.

( ) In exactly the same manner, install the 50 KΩ VERT. GAIN control and a control solder lug at T.

( ) Now connect the front panel to the chassis as shown. Use four 6-32 x 3/8" screw, #6 lockwashers and 6-32 nuts. Make sure that the right and left-hand panel brackets are on the inside of the chassis skirts. They should rest against the chassis proper and not against the flat surface of the circuit board.

( ) Carefully identify the five leads that protrude from the rubber grommet at hole E. The lead that is connected to lug ■ of the filter condenser at A should now be dressed as shown and inserted into the circuit board hole designated XX. Now solder the lead in place exactly as the other components were soldered.

( ) Insert and solder into circuit board hole OO the lead from pin 7 of socket V6.

( ) Dress the lead that runs through hole E from lug ▲ of the filter condenser A and insert it into hole GG on the circuit board. Solder in place as before.

( ) Insert and solder into circuit board hole LL, the lead from lug ▬ of filter condenser A.

( ) Insert and solder into circuit board hole MM, the lead from pin 4 of socket V6.

( ) Connect a wire from lug 1 (S) of control Q to the circuit board at hole WW (S). Allow enough slack so that the wire can be dressed away from the tubes when they are installed.

( ) Connect a wire from lug 2 (S) of control Q to the circuit board at hole VV (S).

( ) Connect a wire from lug 3 (S) of control Q into the circuit board at hole UU (S).

( ) Connect a lead from lug 3 (S) of control R to the circuit board at hole DD (S).

( ) Connect a lead from lug 2 (S) of control R to the circuit board at hole EE (S).

( ) Connect a wire from lug 1 (S) of control R to the circuit board at hole FF (S).

( ) Connect a wire from lug 2 (S) of control S to the circuit board at hole RR (S).

( ) Dress the lead from lug 11 of switch W between panel and chassis and insert and solder it into circuit board hole PP.

( ) Dress the lead from lug 8 of switch W in the same manner and insert and solder it into circuit board hole NN.

( ) Connect the lead from lug 4 of control V to the circuit board at hole BB (S).

( ) Connect a wire from lug 2 (S) of control T into the circuit board at hole KK (S).

SECTION 6

( ) Turn the chassis around as in Pictorial 9 shown on Page 18. Clip both leads of a .1 μfd 400 volt DC tubular condenser to a length of about 1 5/8". Insulate both leads with sleeving and then connect the outside foil lead to solder lug SL4 (S). The sleeving on the other lead should be cut short enough to prevent its coming in contact with the soldering iron when making a connection to the circuit board. Insert this lead into the etched side of the circuit board so that it protrudes through the hole designated JJ. Now solder it in place.

( ) Prepare the other .1 μfd 400 volt DC tubular condenser in the same manner and connect its outside foil lead to lug 9 (S) of switch W. Insert the other lead through hole ZZ from the etched side of the circuit board and solder.

( ) Clip both leads of a 20 μfd 150 volt DC electrolytic condenser to a length of about 1 1/4". Insulate with sleeving and connect the negative (-) lead to lug 1 (S) of control T. Insert the positive lead (+) into the etched side of the circuit board at hole HH and solder.

( ) In the same manner, prepare the remaining 20 μfd 150 volt DC electrolytic condenser and wire the negative (-) lead to lug 1 (S) of control S. Insert the other lead into the etched side of the circuit board at hole YY and solder.

( ) Insulate with sleeving the outside foil lead of a .1 μfd 200 volt DC tubular condenser and connect it to lug 3 (S) of control V. Clip the other lead to a length of about 1 1/4". Insulate and insert it into the etched side of the circuit board at hole QQ. Now solder.

( ) Mount the power transformer to the transformer mounting bracket as shown. Use 8-32 x 1/4" screws, #8 lockwashers and 8-32 nuts. Be sure to orient the color coded leads properly. If the colors are not clear they can be easily identified by scraping away the waxy substance with a sharp edged instrument.

( ) Now mount the transformer and bracket to the chassis from the side shown in Pictorial 9. In this view the green leads should come out on the right side. Use 8-32 hardware.

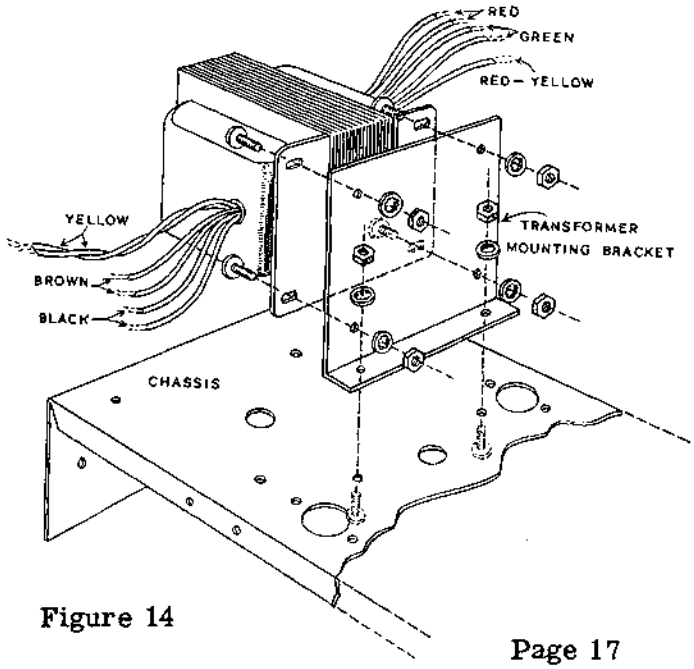
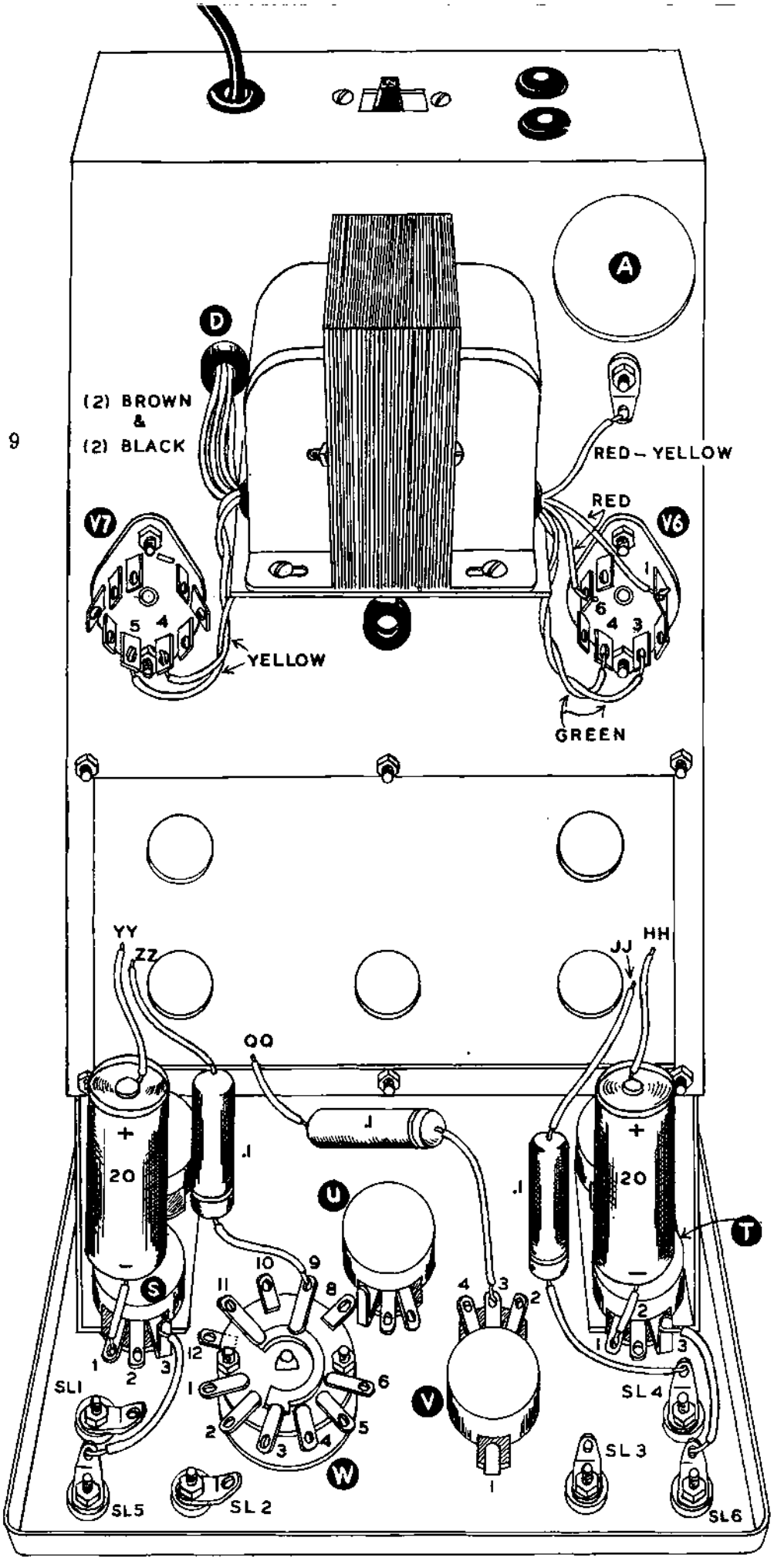


Figure 14

PICTORIAL 9


A
D
(2) BROWN
&
(2) BLACK
RED – YELLOW
RED
V7
V6
YELLOW
GREEN
YY
ZZ
QQ
JJ
HH
+
20
–
.1
U
T
S
SL1
SL 2
SL 3
SL 4
SL5
SL6
V
W

( ) Connect a wire from lug 3 (S) of control S to the #6 solder lug at SL5.

( ) Connect a wire from lug 3 (S) of control T to the #6 solder lug at SL6.

( ) Insert the two brown and the two black transformer leads through the hole in the chassis at D, which is located between the transformer and the two large .1 μfd condensers.

NOTE: If the leads of the power transformer are longer than required, it will be necessary to cut them to proper length before they are connected to their respective terminals.

( ) Twist the two yellow transformer leads together once or twice and connect either one to pin 4 (S) of socket V7. Connect the other yellow lead to pin 5 (S) of V7.

( ) Connect the red-yellow transformer lead to the solder lug (S) at filter condenser A.

( ) Twist the green leads together once or twice and connect either one to pin 4 (S) of socket V6. Connect the other green lead to pin 3 (S) of V6.

( ) Twist the red leads together and connect either one to pin 6 (S) of V6. Connect the other red lead to pin 1 (S) of V6.

SECTION 7

( ) Again turn the 'scope around as in Pictorial 10 shown on Page 20 and connect either black transformer lead from hole D to lug 3 (S) of terminal strip G. Connect the other black lead to lug 1 (S) of terminal strip G.

( ) Now connect the CRT support bracket as shown. Use four 6-32 x 3/8" screws, #6 lock-washers and 6-32 nuts. Move the CRT socket forward to gain access to all three terminal strips located on the bracket.

( ) Identify the four free wires from the chassis hole D. Two of them are brown transformer leads and the other two are hookup wire. Connect the wire from lug 2 of terminal strip B to lug 3 (S) of terminal strip M on the CRT bracket.

( ) Connect the wire from lug ▲ of filter condenser A to lug 4 (S) of terminal strip N.

( ) Twist the brown transformer leads together and connect either one to lug 2 (S) of terminal strip M. Connect the other brown lead to lug 1 (S) of terminal strip M.

( ) Connect the free end of the wire from lug 6 of switch SW to lug 1 (S) of terminal strip L. Check the clearance between the filter condenser can and lug 1 of terminal strip L. Bend the lug away from the can if necessary.

( ) Connect the free end of the wire from lug 3 of switch SW to lug 2 (S) of terminal strip L.

( ) Connect the free end of the wire from lug 5 of switch SW to pin 6 (S) of the CRT socket.

( ) Connect the free end of the wire from lug 2 of switch SW to pin 9 (S) of the CRT socket.

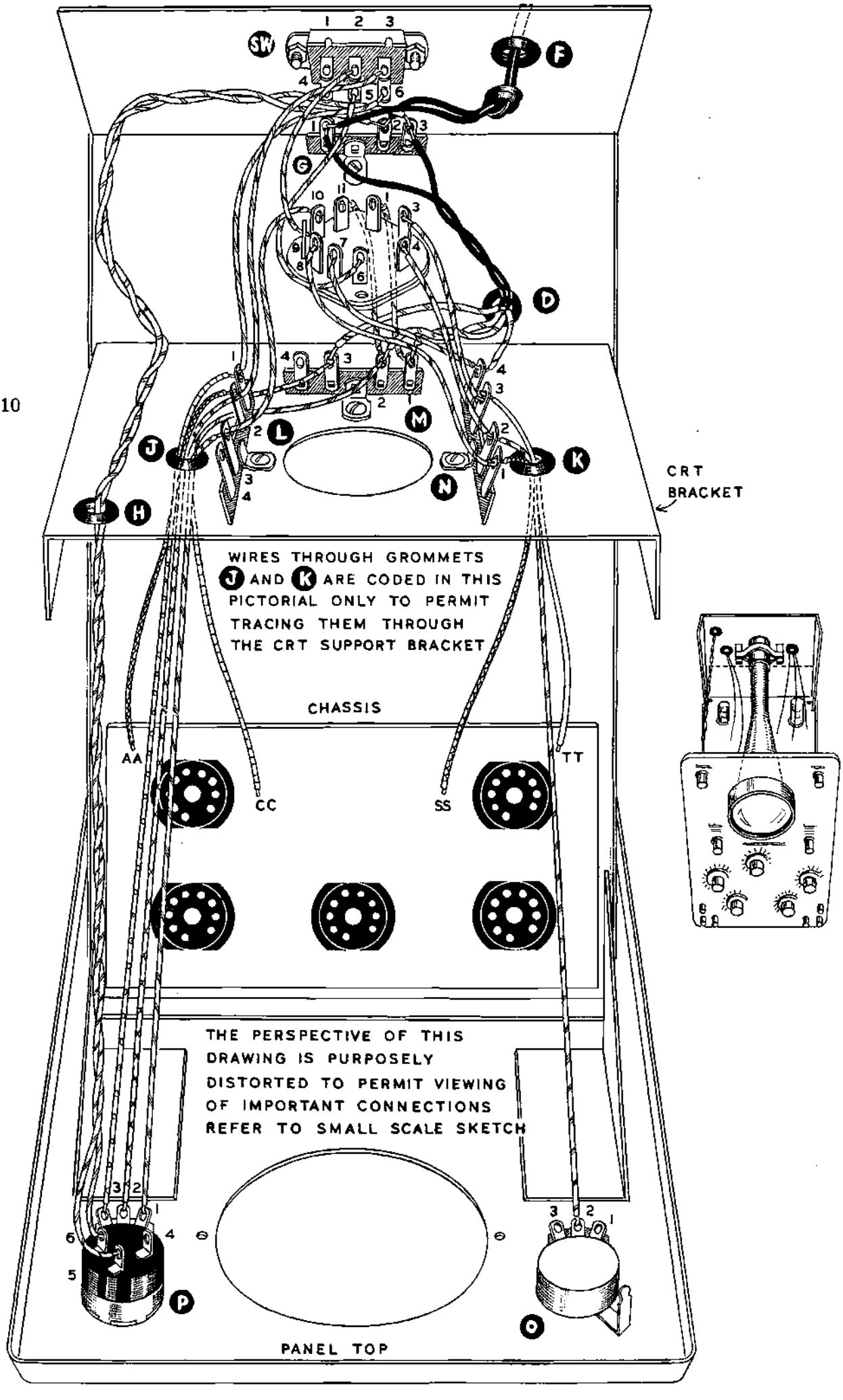
( ) Select the wire that is connected to lug 1 of terminal strip N and inserted through hole K in the CRT support bracket. Insert this wire into the screened side of the circuit board at hole SS (S).

( ) Insert the wire from lug 3 of terminal strip N into the circuit board at hole TT (S).

( ) Connect the wire from lug 2 of terminal strip N to lug 2 (S) of control O.

( ) Identify the wire connected to lug 1 of terminal strip L and inserted through the CRT bracket hole J. Insert this wire into the circuit board hole CC and solder.

PICTORIAL 10



( ) Insert the wire from lug 2 of terminal strip L into the circuit board at hole AA and solder.

( ) Connect the wire from lug 2 of terminal strip M to lug 1 (S) of the INTEN. control P.

( ) Connect the wire from lug 3 of terminal strip L to lug 2 (S) of control P.

( ) Connect the wire from lug 3 of terminal strip M to lug 3 (S) of control P.

( ) The twisted pair of wires connected to lugs 2 and 3 of terminal strip G can now be dressed around the filter condenser can as shown, up one side of the CRT support bracket and through hole H. Connect either wire to lug 5 (S) of control P. Connect the other wire to lug 6 (S) of control P.

FINAL ASSEMBLY AND TESTING

( ) Set the oscilloscope upright so that the rear end rests on the power transformer. Insert the five tubes as indicated on the circuit board. Do not exert a great deal of pressure straight downward into the socket as this might crack the board. The tubes can be inserted easily by rocking them sideways a small amount while pressing downward slightly.

( ) Install the 6X4 tube in socket V6 and the 1V2 tube in socket V7.

( ) Now redress the leads running into the circuit board if necessary so that there is no actual contact between any lead and the glass envelope of a tube.

( ) Carefully insert the cathode ray tube through the panel ring from the front. Rotate it so that the keyway in the tube base is straight downward. The face of the tube should be set back in the ring at least 1/4".

( ) Slip the CRT socket over the pins of the tube.

( ) Clamp the neck of the CRT to the support bracket, using the two tube clamps and cushion strip as shown. Pass the 6-32 x 1" screws through the holes in the top tube clamp, the angle brackets and the bottom tube clamp. Add #6 lockwashers and 6-32 nuts. Do not tighten yet.

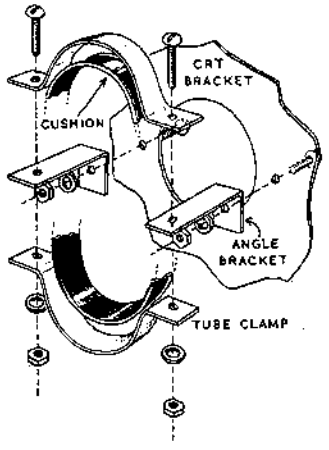


Figure 15

( ) Insert 8-32 x 1/4" set screws in the five larger knobs and 6-32 x 1/8" set screws in the smaller knobs. Place the four small knobs over the following control shafts and tighten the set screws: INTEN., FOCUS, VERTICAL CENTERING, HORIZONTAL CENTERING.

( ) Turn each of the other five shafts completely clockwise. You may require a pair of pliers to turn the shaft of the HOR. SELECTOR switch. Place an indexed knob over each shaft and tighten the set screw with the index line in the following positions:

VERT. GAIN - 100
FREQ. VERNIER - 100
HOR. GAIN - 100
SYNC. AMPLITUDE - 10 EXT.
HOR. SELECTOR - Line between 12 kc and 100 kc

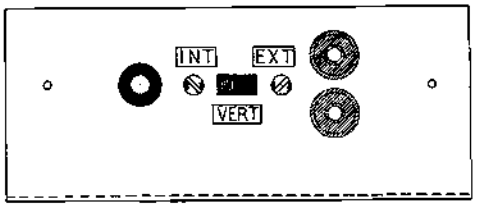


Figure 16

( ) Screw on black binding post caps at the two panel positions marked GND. Install red binding post caps on remaining four binding post bases.

( ) Prepare the adhesive labels as shown and attach them to the rear chassis skirt.

( ) Install the handle on top of the cabinet using the 10-24 x 3/8" screws.

( ) Insert the rubber feet in the bottom of the cabinet as shown.

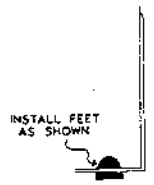


Figure 17

Before attempting to operate the instrument, recheck each step in the wiring against the pictorial diagrams. It is sometimes helpful to mark each lead and component on the diagram with a colored pencil as it is checked. This eliminates the possibility of missing a connection or soldering a lead to a wrong terminal. When satisfied that the wiring is complete and correct, proceed with the testing of the instrument.

CAUTION: The voltages in this instrument are dangerous. Extreme care should be exercised whenever the instrument is connected to the AC line without being installed in its case. Do not connect the line cord to an AC outlet until you have read and fully understand the following instructions on testing the oscilloscope.

Whenever the OL-1 is operated without the cabinet, be sure to remove the line cord from the AC outlet before attempting to change the position of the 'scope on the bench. Some of the highest voltages in the circuit appear on the INTEN. and FOCUS control terminals just below the top edge of the panel. It is easy to get a finger on one of these terminals when moving the OL-1 on the bench.

( ) Set the controls as follows before connecting the line cord to an AC outlet:

INTEN. - Full counterclockwise so that the AC switch will be off.
FOCUS - Approximate center of rotation.
HORIZONTAL CENTERING - Approximate center of rotation.
VERTICAL CENTERING - Approximate center of rotation.
VERT. GAIN - Zero.
HOR. GAIN - Zero.
FREQ. VERNIER - 50.
SYNC. AMPLITUDE - Zero
HOR. SELECTOR - Fully clockwise.

( ) Connect the line cord to a 105-125 volt 50-60 cycle AC outlet.

CAUTION: This instrument will not operate and may be seriously damaged if connected to a DC or 25 cycle AC power source or to an AC line of more than 125 volts.

( ) Turn the INTEN. control full clockwise. This will apply power to the oscilloscope. All tube filaments should now glow, except those in the 1V2 tube. This tube uses a filament voltage of less than one volt and for all practical purposes there will be no glow. Allow one minute for the tubes to reach operating temperature.

( ) Watch the screen of the CRT until a green spot appears. Reduce the brightness of the spot at once by rotating the INTEN. control counterclockwise.

( ) If no spot appears, rotate both the HORIZONTAL and VERTICAL CENTERING controls simultaneously since the controls may position the spot well off the screen. If the spot cannot be located, refer to the trouble-shooting procedure in this manual under the heading IN CASE OF DIFFICULTY.

( ) Now adjust the FOCUS control for minimum spot size.

NOTE: There will be some interaction between the FOCUS and INTEN. controls. By alternately adjusting each one, proper focus at any desired brightness can be obtained.

CAUTION: Do not permit a high intensity spot to remain stationary on the screen for any length of time. This may destroy the fluorescent material on the screen and leave a dark spot.

( ) Rotate the HORIZONTAL CENTERING control and notice that the spot moves horizontally across the screen. Now use the VERTICAL CENTERING control and the spot will move up and down. Adjust these two controls so that the spot is centered on the screen.

( ) With the spot centered, slowly turn the HOR. GAIN control clockwise. The spot should now become a horizontal line that can be extended far beyond the CRT width at maximum horizontal gain. You will also notice that the brightness decreases slightly as the length of the line is increased.

( ) If the trace is not level, indicate the slope of the line with a wax pencil or crayon on the glass face of the CRT. Turn off the power, loosen the tube clamp on the base of the CRT and rotate it slightly until the markings are horizontal. Tighten the clamp and check the trace to see that it is level. CAUTION: Do not attempt to make this adjustment without turning off the instrument. Some socket contacts on the CRT are approximately 1000 volts hot. Contact to these terminals could easily be fatal.

( ) Next turn the HOR. GAIN control to zero and set the HOR. SELECTOR switch to the HOR. INPUT position. Connect a jumper from the 60 CY. TEST post to the VERT. INPUT post. Now advance the VERT. GAIN control clockwise and the spot should become a vertical line that can be extended well beyond the tube diameter.

( ) Adjust the VERT. GAIN control for a trace height of about 1". Move the HOR. SELECTOR switch to the 60 CY. position and slowly advance the HOR. GAIN control clockwise. The vertical line should begin to slant to the left as the HOR. GAIN control is rotated. At maximum horizontal gain, the line will be almost horizontal and it will extend well beyond the tube diameter.

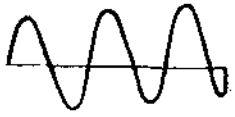


Figure 18

( ) Return the HOR. GAIN control to zero and move the HOR. SELECTOR switch to the line between 15 and 180. Advance the HOR. GAIN control until the pattern reaches a width of about 2". Now adjust the FREQ. VERNIER control until you obtain a pattern similar to that shown. Turn the SYNC. AMPLITUDE control counterclockwise until the trace becomes stable. The Pattern will flicker because the sweep rate is low enough to be detected by the average human eye. The next three positions of the HOR. SELECTOR switch should produce many pattern variations, depending upon the frequency relationships between the 60 cycle voltage applied to the VERT. INPUT post and the sweep generator which is controlled by the HOR. SELECTOR switch in conjunction with the FREQ. VERNIER control.

( ) The chassis should now be installed in the cabinet if the tests are all satisfactory. Pass the line cord through the hole in the back of the cabinet and slip the chassis in until the panel fits snugly around the cabinet rim. Fasten it in place, using two #6 x 3/8" sheet metal screws through the cabinet back into the chassis apron.

This completes the construction and the testing of your oscilloscope.

IN CASE OF DIFFICULTY

If the testing procedure described does not produce the expected results, the following is recommended:

1. Check the wiring against the pictorial diagrams and closely inspect each soldered terminal. Locate each component wired to the circuit board and check their positions and values with the pictorials. Have an acquaintance double check your work because very often an error can be consistently overlooked by the kit builder himself.
2. Check the voltages at the tube socket terminals. The reading should compare within 25% with those listed in the voltage chart. These measurements were made with a Heathkit VTVM with an input resistance of 11 megohms. Voltages may vary greatly when taken with instruments having other input characteristics. Should a serious voltage discrepancy show up, carefully check the components associated with that tube.

3. Check the tubes or have them checked at a reputable service establishment. If possible, use substitute tubes of known quality for comparison because certain types of tube defects do not show up clearly in the average emission tester.

4. If the difficulty seems to be of an intermittent nature, depending upon the physical movement of the circuit board, the metal circuit pattern should be inspected for breaks. These breaks can occur if the board has been severely bent or accidentally dropped. A broken metallic strip can easily be repaired in the following manner: Lay a piece of bare hookup wire along the strip and shape it to the original strip contours. Now solder the wire to the strip a short distance on each side of the break.

5. Should the procedure as outlined fail to correct your difficulty, write to the Heath Company describing the nature of the trouble by giving all possible details, including voltage readings obtained and other indications you may have noticed. We will try to analyze your trouble and advise you accordingly. No charge is made for this service. In all correspondence, refer to this instrument as the model OL-1 Oscilloscope.

VOLTAGE CHART

NOTE: Set all knobs as instructed for testing of Page 22, with the following exceptions:
1. Rotate INTEN. knob clockwise only until the switch clicks.
2. Set HOR. SELECTOR knob to HOR. INPUT position.

SOCKET TUBE TYPE	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8	Pin 9
V1 12AU7	56	NS	1.9	H	H	240	49	120	0
V2 12AU7	270	8.3	21.5	H	H	270	8.3	21.5	0
V3 12AX7	147	NS	1	H	H	170	147	147	0
V4 12AU7	240	49	120	H	H	56	NS	1.9	0
V5 12AU7	270	8.3	21.5	H	H	270	8.3	21.5	0
V6 6X4	360 AC	NC	0	H	NC	360 AC	380		
V7 1V2	NC	NC	NC	870 AC	870 AC	NC	NC	NC	-970
V8 3GP1 CRT	-880	NC	270	-620	NC	270	240	270	270
	Pin 10	Pin 11							
	-915	-880							

NS - not significant
H - heater terminal, 5.7 v to 6.3 v AC
No signal input.

NC - no connection
Line Voltage - 115 volt at 60 cps

All voltages are positive and measured to chassis unless otherwise specified.
Measurements taken with an 11 megohm input VTVM.

CIRCUIT DESCRIPTION

The cathode ray tube consists of:

1. Electron gun, which shoots a stream of electrons toward the face of the tube which is coated with a fluorescent material. This causes the tube face to light up wherever the electrons strike.

2. Control Grid, which controls the number of electrons that strike the tube and consequently the brightness of the trace. The potential on this tube element is set up by the operator by means of the intensity control.

3. Focusing Anode, which has the ability to converge the electron stream into a single beam of variable diameter. The focus control makes it possible to reduce the size of the beam and obtain a very small spot on the tube face.

4. Accelerating Anode, which operates in conjunction with the focusing anode and speeds the electrons on their way. The potential at this element is fixed.

5. Two Vertical Deflection Plates, which are set at right angles to the direction of flow of electrons. The potential difference between the plates will bend the beam either up or down. A DC difference is set up for centering purposes by means of the vertical centering control.

6. Two Horizontal Deflection Plates, which operate in the same manner as the vertical plates except that their effect on the electron beam is in the horizontal direction. The horizontal centering control provides the necessary centering adjustment.

To increase the overall sensitivity of the instrument, both horizontal and vertical amplifiers are used. This makes it possible to observe clearly the wave forms of voltages of very small amplitudes. For applications such as the checking of modulation percentage of an RF carrier where the frequency response of the vertical amplifiers is inadequate, direct connection to the vertical deflection plates of the CRT are available.

A linear time base is provided by the internal sweep generator which produces a sawtooth type voltage of variable frequency. This voltage, when applied to the horizontal deflection plates, causes the spot to move at a fixed rate across the tube face from left to right. It then returns quickly to the left side to begin the next sweep. Any voltage applied to the vertical deflection plates will cause the beam to be displaced vertically at the same time. Thus the actual wave form is displayed in addition to a comparison between its repetition rate and time.

Provisions are also made so that an externally generated sweep voltage or an AC voltage at line frequency can be used in place of the built-in sweep generator.

OPERATION OF THE OSCILLOSCOPE

The operation of an oscilloscope and its many controls is quite simple once the basic principles are clear. The controls can be divided into groups with specific functions.

Two knobs marked INTEN. and FOCUS control the quality of the trace. Disregarding normal interaction, the INTEN. knob adjusts brightness and the FOCUS knob the sharpness of the trace on the oscilloscope screen.

Two knobs marked VERTICAL CENTERING and HORIZONTAL CENTERING control the location of the trace on the screen. Turning the vertical knob shifts the trace up and down and the horizontal knob moves the trace left or right.

One knob marked VERT. GAIN controls the height of the pattern.

One knob marked HOR. GAIN controls the width of the pattern.

Three knobs marked HOR. SELECTOR, FREQ. VERNIER and SYNC. AMPLITUDE control the operation of the sweep generator. The HOR. SELECTOR and the FREQ. VERNIER controls permit selection of a suitable sweeping rate to provide a clear pattern. The SYNC. AMPLITUDE knob provides the stabilizing action needed to keep the pattern from drifting left or right. From 0 to 10 counterclockwise, it will synchronize the sweep generator with the applied vertical signal. Clockwise, the sweep generator can be synchronized with a signal applied to the EXT. SYN. post.

In order to couple a signal directly to the vertical deflection plates of the CRT, the DPDT switch at the rear of the oscilloscope must be moved to the EXT. position. The signal is then applied across the two banana jack terminals next to the switch. Polarity is not an important consideration because neither of the vertical deflection plates are grounded within the scope itself. The vertical deflection sensitivity of the CRT and the amplitude of the applied signal will determine the height of the pattern.

For the safety of the operator, B+ potential is blocked from the banana jacks by the two .005 μfd disc ceramic condensers. They also serve to maintain the use of the VERTICAL CENTERING control by preventing the virtual shorting of the vertical deflection plates through a low impedance signal source. The VERT. GAIN control however, will have no effect. In all oscilloscope applications requiring the use of vertical amplifiers, the DPDT switch should be in the INT. position.

REPLACEMENTS

Material supplied with Heathkits has been carefully selected to meet design requirements and ordinarily will fulfill its function without difficulty. Occasionally improper instrument operation can be traced to a faulty tube or component. Should inspection reveal the necessity for replacement, write to the Heath Company and supply all of the following information:

A. Thoroughly identify the part in question by using the part number and description found in the manual parts list.
B. Identify the type and model number of kit in which it is used.
C. Mention the order number and date of purchase.
D. Describe the nature of defect or reason for requesting replacement.

The Heath Company will promptly supply the necessary replacement. Please do not return the original component until specifically requested to do so. Do not dismantle the component in question as this will void the guarantee. If tubes are to be returned, pack them carefully to prevent breakage in shipment as broken tubes are not eligible for replacement. This replacement policy does not cover the free replacement of parts that may have been broken or damaged through carelessness on the part of the kit builder.

If the circuit board has been accidently damaged through breakage, the excessive use of solder, through the use of acid or paste fluxes or for any other reason, a complete repair kit is available. The Heathkit Repair Kit R-OL-1 for the OL-1 Oscilloscope will consist of the etched circuit board and all sockets, resistors and condensers to be mounted directly on the board itself. The price is $5.00 plus postage. A replacement for the horizontal selector switch is available as a separate item for $.75 plus postage.

SERVICE

In event continued operational difficulties of the completed instrument are experienced, the facilities of the Heath Company Service Department are at your disposal. Your instrument may be returned for inspection and repair for a service charge of $5.00 plus the cost of any additional material that may be required. THIS SERVICE POLICY APPLIES ONLY TO COMPLETED INSTRUMENTS CONSTRUCTED IN ACCORDANCE WITH THE INSTRUCTIONS AS STATED IN THE MANUAL. Instruments that are not entirely completed or instruments that are modified in design will not be accepted for repair. Instruments showing evidence of acid core solder or paste fluxes will be returned not repaired.

The Heath Company is willing to offer its full cooperation to assist you in obtaining the proper operation of your instrument and therefore this factory repair service is available for a period of one year from the date of purchase.

SHIPPING INSTRUCTIONS

Before returning a unit for service, be sure that all parts are securely mounted. Attach a tag to the instrument giving name, address and trouble experienced. Pack in a rugged container, preferably wood, using at least three inches of shredded newspaper or excelsior on all sides. DO NOT SHIP IN THE ORIGINAL KIT CARTON AS THIS CARTON IS NOT CONSIDERED ADEQUATE FOR SAFE SHIPMENT OF THE COMPLETED INSTRUMENT. Ship by prepaid express if possible. Return shipment will be made by express collect. Note that a carrier cannot be held liable for damage in transit if packing, in HIS OPINION, is insufficient.

SPECIFICATIONS

All prices are subject to change without notice. The Heath Company reserves the right to discontinue instruments and to change specifications at any time without incurring any obligation to incorporate new features in instruments previously sold.

WARRANTY

The Heath Company limits its warranty of parts supplied with any kit (except tubes, meters and rectifiers, where the original manufacturer's guarantee only applies) to a period of three (3) months from the date of purchase. Replacement will be made only when said part is returned postpaid, with prior permission and in the judgment of the Heath Company was defective at the time of sale. This warranty does not extend to any Heathkits which have been subjected to misuse, neglect, accident and improper installation or applications. Material supplied with a kit shall not be considered as defective, even though not in exact accordance with specifications, if it substantially fulfills performance requirements. This warranty is not transferable and applies only to the original purchaser. This warranty is in lieu of all other warranties and the Heath Company neither assumes nor authorizes any other person to assume for them any other liability in connection with the sale of Heathkits.

The assembler is urged to follow the instructions exactly as provided. The Heath Company assumes no responsibility or liability for any damages or injuries sustained in the assembly of the device or in the operation of the completed instrument.

SOME OSCILLOSCOPE APPLICATIONS

As mentioned in the introduction to this manual, the cathode ray oscilloscope is a most versatile device. It has the ability to measure the basic electrical quantities and more important, to show the relationship between any two of these quantities at any one time. Or, it can relate any one of the variables against a controlled time reference. Therefore, it can indicate such characteristics as frequency, phase relations and wave form.

By the use of supplementary devices called transducers, a great variety of other physical attributes can be investigated with the oscilloscope. These transducers are used to convert sound, heat, light, stress or physical movement into electrical impulses. The impulses can be studied by displaying them on the screen of the oscilloscope.

The following portion of this manual is simply to familiarize you with the basic applications of your oscilloscope. Each one of the uses described is well within the capabilities of the Heathkit model OL-1 Oscilloscope.

Waveform Investigation: Probably the major use of most oscilloscopes is in the study of recurrent or transient variations in an electrical quantity. Since the oscilloscope is a voltage operated device, these variations must be first converted into changes in voltage.

It is common practice to apply the signal voltage to the vertical input to the oscilloscope. By the use of amplifiers, this voltage is made to displace vertically the electron beam in the cathode ray tube. At the same time, the beam is being swept horizontally by the sweep generator within the instrument. The sweep frequency is normally a sub-harmonic or simple fraction of the signal frequency. Therefore, more than one complete cycle of the signal is shown on the screen.

With this brief background, we have described below the more common application of the oscilloscope in studying wave forms.

Testing Audio Amplifiers and Circuits: Figure 19 shows the conventional set-up of equipment for this application. The audio generator should be capable of producing a pure sine wave with a very low harmonic distortion. The load resistor should match the output impedance of the amplifier. The usual practice is to perform all tests at an input voltage sufficient only to develop a reference power output. This prevents overloading of any portion of the amplifier and consequent inaccuracies in measurements.

Figure 19

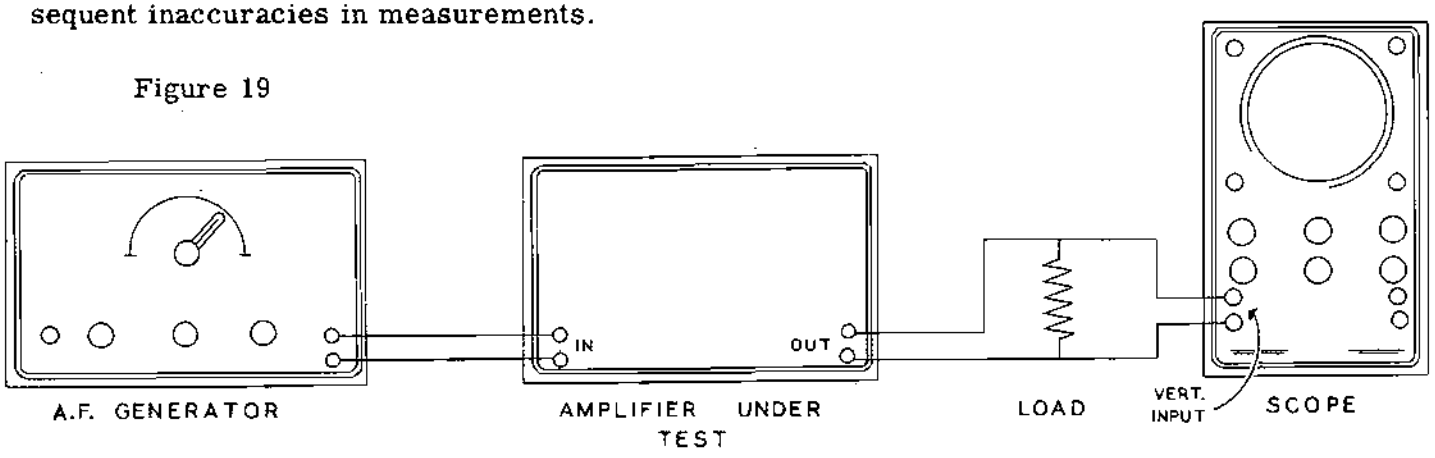


Figure 20A shows serious flattening of one peak representing about 10% harmonic distortion. This condition may be caused by incorrect bias on any stage or by an inoperative tube in a push-pull stage. Figure 20B indicates third harmonic distortion, a particularly objectionable fault. Figure 20C shows flattening of both peaks, usually an indication of overload somewhere in the circuit.

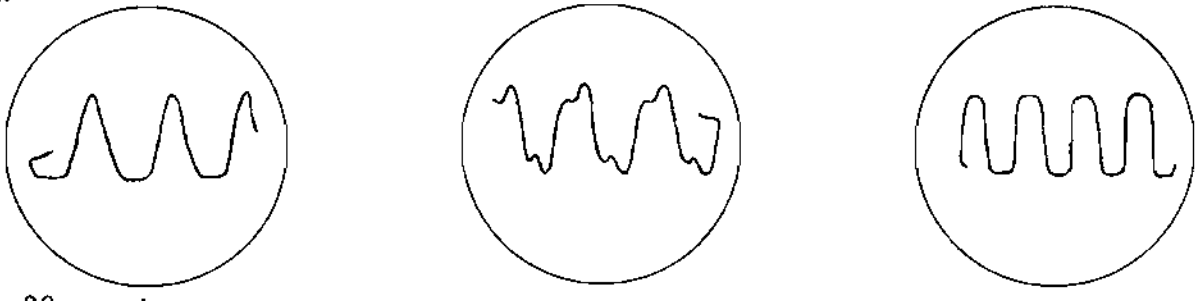


Figure 20

Although the use of sine wave input tells us a lot about an amplifier, the use of a square wave input waveform gives a very accurate and extremely sensitive indication of the performance of the system with respect to both amplitude distortion and phase shift. Assume that we apply a wave of the form shown in Figure 21A with a fundamental frequency of 60 cycles. In a theoretically perfect amplifier, the output wave form would be an exact duplicate except at a greater power level as determined by the gain of the amplifier. Actually, the distortion of this waveform as shown in the scope tells a great deal about the amplifier at frequencies considerably separated from the test frequency. If the high frequency performance of the amplifier is excellent, the front of the wave form will be sharp cornered and clean.

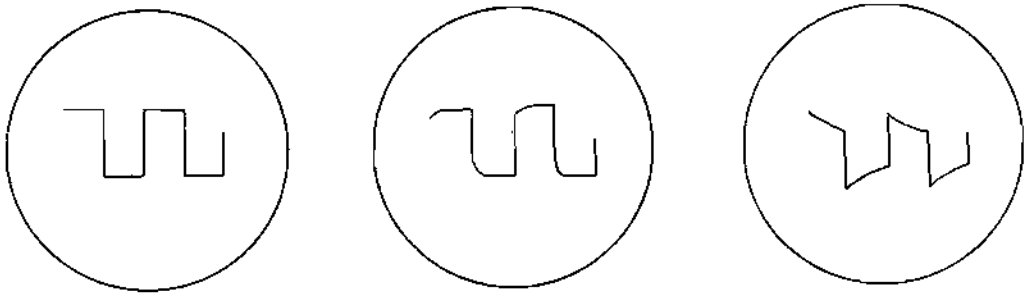


Figure 21

A distortion similar to that shown in Figure 21B indicates a poor high frequency response, which may be amplitude distortion, phase shift or both. We may assume therefore, that the shape of the rising portion of the waveform indicates the ability of the amplifier to faithfully reproduce high frequencies. Conversely, the slope of the flat top portion of the wave, indicates the performance of the amplifier in the low frequency range. Figure 21C is the characteristic indication of an amplifier with a poor low frequency response.

Again, the square wave generator used must be capable of producing the desired waveform with excellent voltage regulation and low inherent distortion. The Heathkit model AO-1 Audio Oscillator is recommended.

Further discussion of this method is beyond the scope of this manual. Interested readers are referred to the bibliography for further sources.

Servicing Television Receivers: Servicing of television receivers is a rapidly expanding application of the cathode ray oscilloscope. Each of the following basic uses require some additional equipment, but none of them can be performed without using the oscilloscope.

Alignment of a television receiver is virtually impossible without the use of an oscilloscope and a television alignment sweep generator such as the Heathkit TS Series. This type of generator supplies an RF signal over all the frequencies involved in modern television receiver operation. The signal can be frequency modulated at 60 cycles per second with a deviation of several megacycles. The generator also provides a 60 cycle sweep voltage controllable in phase to drive the horizontal deflection amplifiers in the oscilloscope. It also provides a blanking system which cuts off the RF output of the generator during one-half of its operating cycle. In effect, the generator output starts at a reference frequency and sweeps alternately at a uniform rate from the reference frequency to frequencies several megacycles above and below. The vertical input to the scope is driven by the voltage developed at the input of the video amplifier. Since this voltage varies in exact accordance with the gain of the RF and/or IF amplifier stages over the frequency range being swept, the trace on the scope screen is actually a graphic representation of the response of the amplifiers being tested.

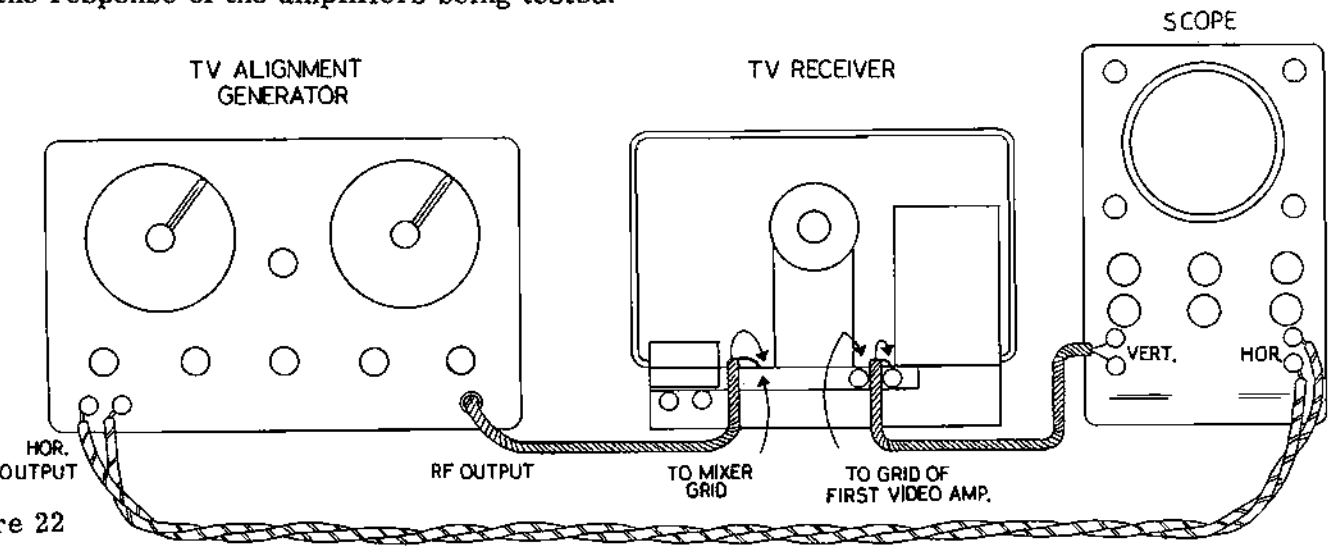


Figure 22

Figure 22 outlines the connections between the alignment generator, the receiver and the oscilloscope. The exact procedure for alignment varies greatly. This information is generally available in the manufacturers service information. Usually a drawing of the desired response curve is given together with a sequence of adjustments to roughly approach the desired pattern. Final adjustments are made while watching the trace on the oscilloscope.

The waveform of the complex television picture signal as it is passed through the receiver is undoubtedly the most important characteristic of the signal voltage. In order to properly display the minute variations in waveform which incidentally make up the difference between good and bad picture quality, the oscilloscope is required to amplify and display voltage changes over an extremely wide frequency range without distorting them.

Again, you must rely upon the manufacturer to furnish representative patterns showing the waveform to be expected at specific points within the receiver. You will find that these diagrams cover the entire receiver with the exception of the front end or tuner portion. However, in order to pick off the modulation envelop in the IF or video amplifier sections, a demodulator probe is used to make connections to the plate, grid or cathode of the stage being investigated. This is necessary since the signal in these stages is still contained in the amplitude modulation envelope of the carrier and must be detected or demodulated before it can be shown on the oscilloscope.

The Heathkit Demodulator Probe is designed for this purpose. At any point after the video detector, no such probe is necessary and a simple shielded low capacity cable can be used.

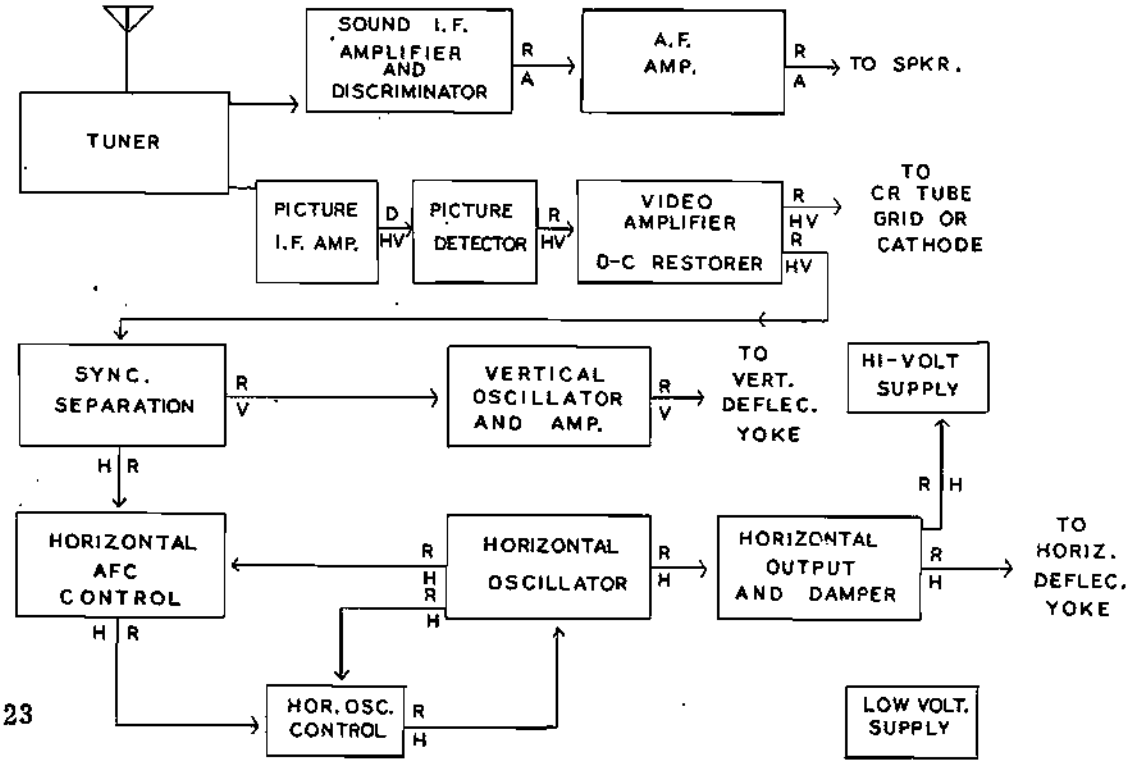


Figure 23

OPERATE OSCILLOSCOPE AS SHOWN BELOW:

R Use direct input.
D Use demodulated input.
H Use 7,875 or 15,750 cps sweep.
V Use 20,30 or 60 cps sweep.
A Use audio test frequency sweep or half this frequency.

NOTE: For simplicity, all amplifier stages are shown within one block in the diagram. Tests may be made at the input or output of individual amplifier stages using the indicated mode of operation.

In either case, the signal voltage is fed into the vertical amplifier of the oscilloscope as shown in Figure 23. At any point up the video detector, the voltages picked off will be quite small and considerable vertical gain will be required. Within the sync circuits and deflection circuits, however, these voltages reach very respectable proportions and very little amplification is required.

In checking waveform, remember that two basic frequencies are involved in the television signal. The vertical or field frequency is 60 cycles per second. Any investigation of the circuit except within the horizontal oscillator, its differentiator network and the horizontal amplifier stages can generally be made using a sweep generator frequency of 20 to 30 cycles, thus showing two or three complete fields of the signal. In order to study the horizontal pulse shape or the operation of the horizontal deflection system, it is generally necessary to operate the sweep generator at 15,750 or 7,875 cycles per second. This sweep rate will show the waveform of one or two complete lines of the signal.

The signal tracing method of analysis is most helpful in going through a receiver in this fashion, since faulty receiver operation is generally caused by the loss of all or a significant portion of the picture information and pulses at some stage within the receiver. With a basic understanding of the function of each part of the signal and with the means available to determine what the signal actually looks like at any part of this receiver, it is a comparatively simple matter to isolate the defective portion and the particular component causing the failure.

Remember in making connections to the test points that grid circuits are generally high impedance points and that the addition of any capacity can disrupt the performance of the stage to some degree. Plate circuits and cathode circuits are usually lower impedance points and more desirable for testing purposes. Also bear in mind that the plate circuit indication with respect to polarity will be exactly opposite to indications obtained on grid or cathode, since a phase difference of 180 degrees takes place within the tube. Therefore, the pattern shown on the scope screen may be inverted when such interchanges are made. The form of the wave will not be changed, however.

Video amplifier response can be measured in exactly the same manner described for testing audio amplifiers and again a square wave signal is the most efficient method to use. Because a video amplifier must pass signals as low as 20 cycles and as high as 4 or 5 megacycles, a more comprehensive test is required. Usually a 60 cycle check is made to cover low and medium frequency characteristics. A second check at 25 kc covers the high frequency portion of the response curve. Again such tests require accuracy on the part of the oscilloscope. The signal tracing technique can be used in these tests also. The square wave generator is fed directly into the first video amplifier grid. Very low signal input will be required. Then the oscilloscope is connected to various plates starting near the output end and working back until any distortion is isolated. Patterns such as Figure 21B are responsible for poor picture detail or fuzziness, while distortion of the waveform shown in Figure 21C can cause shading of the picture from top to bottom.

Observing Modulation Patterns: Amateur radio operaters often use the oscilloscope to check the quality of modulated RF signals obtained from their transmitters. Since the vertical amplifier frequency response of the oscilloscope is not adequate to accurately reproduce the frequencies of the RF carrier, direct connections to the vertical deflection plates of the cathode ray tube are required. These connections are available at the rear of the Heathkit model OL-1.

When using the oscilloscope for this purpose, the operator generally relies on the trapezoidal pattern for test purposes. Such a pattern is formed when a modulated RF signal is applied to the vertical deflection plates of the cathode ray tube and the modulating audio signal used for horizontal deflection. This modulating signal can be applied to the horizontal input terminals of the oscilloscope.

The appearance of a typical trapezoidal pattern is given in Figure 24A. As the modulation percentage increases, the pattern becomes more triangular in shape, approaching a perfect triangle with 100% modulation as shown in Figure 24B. Over modulation gives patterns shown in Figure 24C.

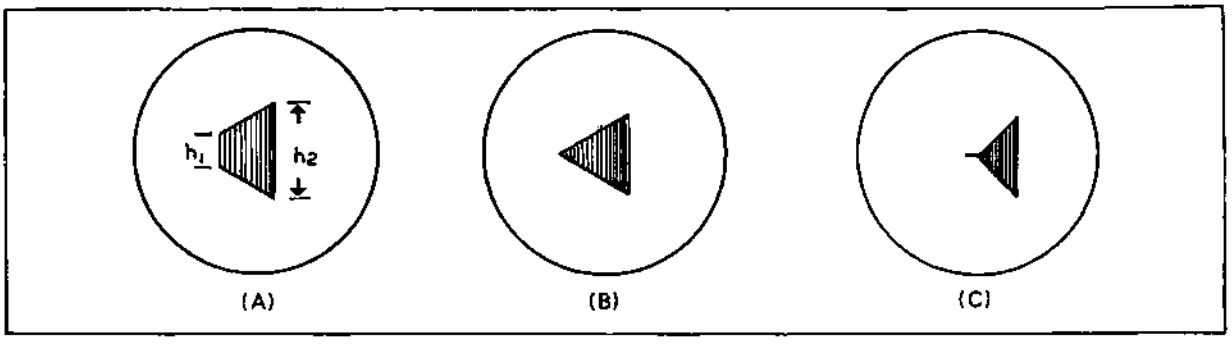


Figure 24

A trapezoidal pattern is useful for determining percentage modulation. The maximum (h2) and minimum (h1) heights of the trapezoid are measured using any convenient unit. Percentage of modulation may then be calculated as follows:

$$\text{Percentage modulation} = (h2 - \frac{h1}{h2} + h1) \times 100$$

Trapezoidal patterns are also useful for indicating the operational characteristics of RF signals obtained from carrier current transmitters, phono oscillators and similar devices. Typical patterns that may be obtained are shown in Figure 25.

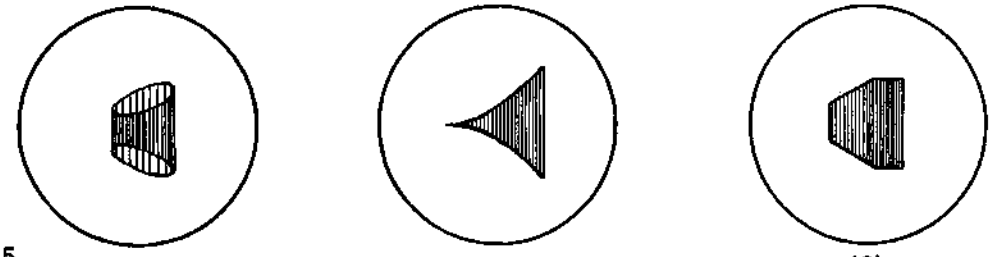


Figure 25

Figure 25A shows the type of pattern obtained with less than 100% modulation, but with phase shift in the audio signal between the point at which the audio signal is taken for the oscilloscope horizontal deflection and the point at which carrier modulation occurs. Such a pattern corresponds essentially to the pattern given in Figure 24A. It does not indicate a defect or improper operation.

Figure 25B gives the type of pattern obtained where an improperly operated Class C, RF amplifier is used. Such a pattern may be caused by regeneration, improper neutralization or excessive bias.

The pattern shown in Figure 25C may be caused by insufficient RF grid drive to a modulated amplifier or a weak amplifier tube. Saturation is reached on the modulated peaks, resulting in the flattened appearance.

Miscellaneous Waveform Measurements: In this category we can place such waveform investigations as studies of noise and vibration, sub-sonic and super-sonic applications and hundreds of others. Each of these fields is highly specialized and it is obviously impossible to cover them here. We again refer you to the bibliography for further reading in this field.

AC Voltage Measurements: Because of its peculiar characteristics, the oscilloscope is particularly suited to the measurement of AC voltages. With the advent of television, it has become imperative that such measurements be made accurately without respect to wave shape, so that the conventional RMS reading AC voltmeter is no longer adequate. Most television service bulletins specify peak-to-peak voltages which appear at various points of the circuit. Other applications for such measurements are becoming more common every day.

The OL-1 can be used to accurately measure and display these voltages. It can be calibrated by any one of many methods for this purpose. The Heathkit model VC-2 Voltage Calibrator is particularly recommended.

When using the oscilloscope for AC voltage measurements, it is sometimes helpful to use the horizontal input setting for the horizontal selector switch. This produces a vertical line which can be focused and centered exactly for most accurate readings.

The following relationships exist between sine wave AC voltages:

RMS x 1.414 = Peak Voltage
RMS x 2.828 = Peak-to-Peak Voltage
Peak Voltage x 0.707 = RMS Voltage
Peak-to-Peak Voltage x 0.3535 = RMS Voltage

AC Current Measurements: To measure AC currents, the unknown current must be passed through a resistor of known value. The voltage drop across this resistor is measured as described above. From Ohm's Law, $I = \frac{E}{R}$ the current can be calculated. It is important that the resistor be non-reactive at the frequency involved. It should also be relatively small with respect to the resistance of the load.

Frequency Measurements: Frequency measurements can be made with an accuracy limited only by the reference frequency source available. In most cases, this can be the 60 cycle line frequency which is usually controlled very closely. The unknown frequency is applied to the vertical input and the reference frequency to the horizontal input. The internal sweep generator is not used. The resultant pattern may take on any one of a number of shapes. Typical patterns are shown below.

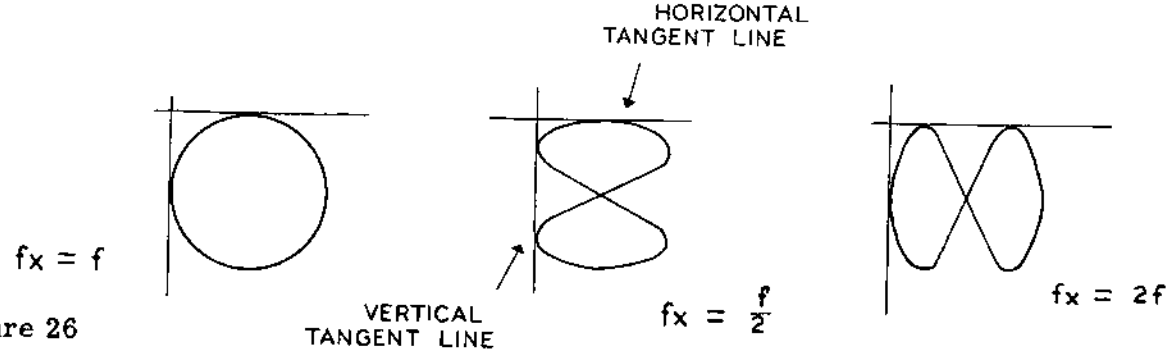


Figure 26

The frequency ratio can be calculated from the formula, $f_x = \frac{Th \times f}{Tv}$ where f_x is the unknown frequency; Th is the number of loops which touch the horizontal tangent line; Tv is the number of loops which touch the vertical tangent line.

When using Lissajous figures as these curves represent, it is good practice to have the figure rotating slowly rather than stationary. This eliminates the possibility of an error in counting the tangent points. If the pattern is stationary, a double image may be formed. In such cases, the end of the trace should be counted as one-half a tangent point rather than a full point. This condition may occur when neither frequency can be varied.

Phase Measurements: It is sometimes necessary to determine the phase relationship between two AC voltages of the same frequency. This can be accomplished quite easily by applying one of the voltages to the horizontal input and the other voltage to the vertical input. The phase relationship can be estimated from the figures below.

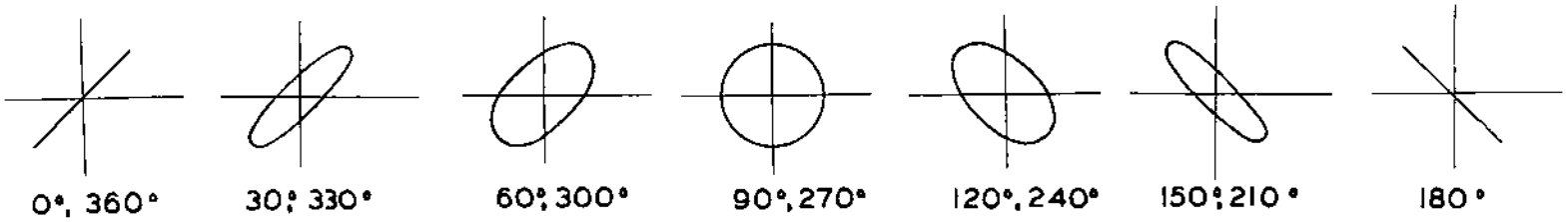


Figure 27

To calculate the phase relationship, use the following formula: $\sin \Phi = \frac{A}{B}$

The distance A is measured from the X axis to the intercept point of the trace and the Y axis. The distance B represents the height of the pattern above the X axis. The axis of the ellipse must pass through the point O.

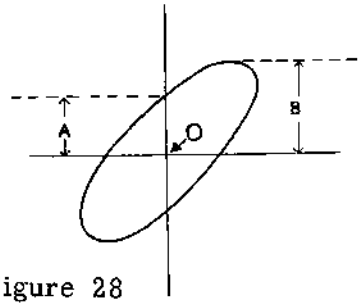


Figure 28

BIBLIOGRAPHY

While many issues of the popular radio and service magazines have carried excellent articles on the construction and application of oscilloscopes, and their reading is highly recommended, we also suggest the following excellent books:

Ruiter; Modern Oscilloscopes and Their Uses
Sylvania; How to Service Radios With an Oscilloscope
Hickok; How to Use the CR Oscilloscope in Servicing Radio and TV
Rider; The Cathode Ray Tube at Work
Turner; Radio Test Instruments
Editors and Engineers; Radio Handbook
A. R. R. L.; Radio Amateurs Handbook
Rider and Uslan; Encyclopedia on Cathode Ray Oscilloscope and Their Uses

The Heath Company is willing to offer its full cooperation to assist you in obtaining the specified performance level in your instrument. Factory repair service is available for a period of one year from the date of purchase or you may contact the Engineering Consultation Department by mail. For information regarding the possible modification of existing kits, the volumes listed in the Bibliography section are recommended. They can be obtained at or through your local library, as well as at any electronic outlet store. Although the Heath Company sincerely welcomes all comments and suggestions, it would be impossible to design, test, evaluate and assume responsibility for proposed circuit changes for specific purposes. Therefore, such modifications must be made at the discretion of the kit builder according to information which will be much more readily available from some local source.

PART No.	PARTS Per Kit	DESCRIPTION
Resistors		
1-9	3	1 KΩ 1/2 watt
1-44	5	2.2 KΩ 1/2 watt
1-14	1	3.3 KΩ 1/2 watt
1-20	5	10 KΩ 1/2 watt
1-22	1	22 KΩ 1/2 watt
1-25	3	47 KΩ 1/2 watt
1-26	4	100 KΩ 1/2 watt
1-27	1	150 KΩ 1/2 watt
1-29	1	220 KΩ 1/2 watt
1-33	1	470 KΩ 1/2 watt
1-35	3	1 megohm 1/2 watt
1-37	6	2.2 megohm 1/2 watt
1-5A	2	22 KΩ 1 watt
1-32A	1	470 KΩ 1 watt
1-11B	4	22 KΩ 2 watt
Condensers		
21-9	1	100 μμf disc ceramic
21-14	1	.001 μfd disc ceramic
21-27	4	.005 μfd disc ceramic
21-16	1	.01 μfd disc ceramic
21-31	3	.02 μfd disc ceramic
23-28	4	.1 μfd 200 vdc tubular
23-53	2	.1 μfd 400 vdc tubular
23-29	2	.1 μfd 1200 vdc tubular
25-19	2	20 μfd 150 vdc electrolytic
25-21	1	20-20-20-20 μfd 450 vdc elec
Controls-Switches		
10-11	4	50 KΩ
19-25	1	50 KΩ w/SPST switch
10-13	1	200 KΩ center tapped
10-14	1	250 KΩ
10-28	1	7500 KΩ
60-2	1	DPDT slide switch
63-83	1	6-position rotary switch
Tubes		
411-25	4	12AU7
411-26	1	12AX7
411-64	1	6X4
411-65	1	1V2
411-66	1	3GP1 cathode ray
Wire		
344-1	1	length Hookup wire
346-1	2	length Sleeving
89-1	1	Line cord
Sockets-Terminal Strips		
434-15	1	7-pin tube socket
434-16	1	9-pin tube socket
434-46	5	9-pin tube socket
434-48	1	11-pin CRT socket
431-2	1	2-lug terminal strip
431-3	1	3-lug terminal strip
431-5	3	4-lug terminal strip

PART No.	PARTS Per Kit	DESCRIPTION
Hardware		
250-2	10	3-48 x 1/4 screw
250-8	4	#6 x 3/8 sheet metal screw
250-9	18	6-32 x 3/8 screw
250-13	2	6-32 x 1 screw
250-17	6	8-32 x 1/4 screw
250-19	2	10-24 x 3/8 screw
250-33	4	6-32 x 1/8 set screw
250-43	5	8-32 x 1/4 set screw
252-1	10	3-48 hex nut
252-3	26	6-32 hex nut
252-4	6	8-32 hex nut
252-7	9	Control nut
252-9	2	Speednut
75-17	12	Insulator bushing
254-7	6	#3 lockwasher
253-10	9	Control washer
254-1	20	#6 lockwasher
254-2	6	#8 lockwasher
254-4	4	Control lockwasher
259-1	8	#6 solder lug
259-10	5	Control solder lug
Knobs-Terminals		
100-M16B	2	Binding post cap, black
100-M16R	4	Binding post cap, red
427-2	6	Binding post base
436-3	2	Banana jack, red
437-1	2	Banana jack insert
462-19	5	Indexed knob
462-30	4	Knob
Sheet Metal Parts		
90-32	1	Cabinet
200-M69	1	Chassis
203-64F82	1	Panel
204-M68	2	Angle bracket
204-M71	1	CRT support bracket
204-M72	1	Transformer mounting bracket
204-M73L	1	Triangular panel bracket, left
204-M73R	1	Triangular panel bracket, right
207-M1	2	CRT clamp
210-M4	1	Panel ring assembly
Miscellaneous		
54-24	1	Power transformer
73-1	6	3/8 rubber grommet
73-5	1	Rubber cushion strip
85-5F84	1	Circuit board
211-1	1	Handle
261-1	4	Rubber feet
390-16	1	Label set
481-1	1	Condenser mounting wafer
595-93	1	Manual

HELPFUL KIT BUILDING INFORMATION

Before attempting actual kit construction read the construction manual through thoroughly to familiarize yourself with the general procedure. Note the relative location of pictorials and pictorial inserts in respect to the progress of the assembly procedure outlined.

This information is offered primarily for the convenience of novice kit builders and will be of definite assistance to those lacking thorough knowledge of good construction practices. Even the advanced electronics enthusiast may benefit by a brief review of this material before proceeding with kit construction. In the majority of cases, failure to observe basic instruction fundamentals is responsible for inability to obtain desired level of performance.

RECOMMENDED TOOLS

The successful construction of Heathkits does not require the use of specialized equipment and only basic tools are required. A good quality electric soldering iron is essential. The preferred size would be a 100 watt iron with a small tip. The use of long nose pliers and diagonal or side cutting pliers is recommended. A small screw driver will prove adequate and several additional assorted screw drivers will be helpful. Be sure to obtain a good supply of rosin core type radio solder. Never use separate fluxes, paste or acid solder in electronic work.

ASSEMBLY

In the actual mechanical assembly of components to the chassis and panel, it is important that the procedure shown in the manual be carefully followed. Make sure that tube sockets are properly mounted in respect to keyway or pin numbering location. The same applies to transformer mountings so that the correct transformer color coded wires will be available at the proper chassis opening.

Make it a standard practice to use lock washers under all 6-32 and 8-32 nuts. The only exception being in the use of solder lugs—the necessary locking feature is already incorporated in the design of the solder lugs. A control lock washer should always be used between the control and the chassis to prevent undesirable rotation in the panel. To improve instrument appearance and to prevent possible panel marring use a control flat nickel washer under each control nut.

When installing binding posts that require the use of fiber insulating washers, it is good practice to slip the shoulder washer over the binding post mounting stud before installing the mounting stud in the panel hole provided. Next, install a flat fiber washer and a solder lug under the mounting nut. Be sure that the shoulder washer is properly centered in the panel to prevent possible shorting of the binding post.

WIRING

When following wiring procedure make the leads as short and direct as possible. In filament wiring requiring the use of a twisted pair of wires allow sufficient slack in the wiring that will permit the twisted pair to be pushed against the chassis as closely as possible thereby affording relative isolation from adjacent parts and wiring.

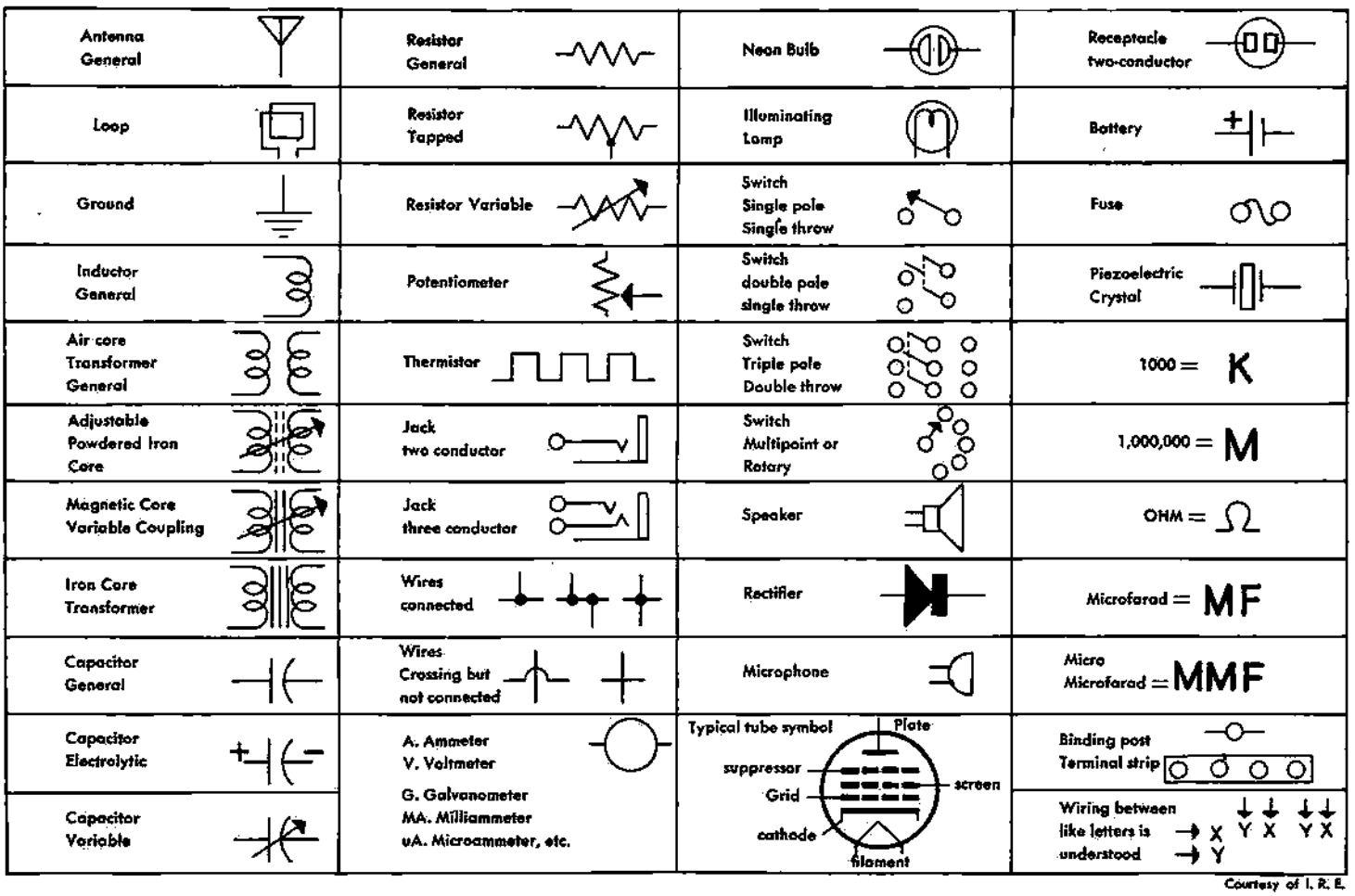
When removing insulation from the end of hookup wire, it is seldom necessary to expose more than a quarter inch of the wire. Excessive insulation removal may cause a short circuit condition in respect to nearby wiring or terminals. In some instances, transformer leads of solid copper will have a brown baked enamel coating. After the transformer leads have been trimmed to a suitable length, it is necessary to scrape the enamel coating in order to expose the bright copper wire before making a terminal or soldered connection.

In mounting parts such as resistors or condensers, trim off all excess lead lengths so that the parts may be installed in a direct point-to-point manner. When necessary use spaghetti or insulated sleeving over exposed wires that might short to nearby wiring.

It is urgently recommended that the wiring dress and parts layout as shown in the construction manual be faithfully followed. In every instance, the desirability of this arrangement was carefully determined through the construction of a series of laboratory models.

SOLDERING

Much of the performance of the kit instrument, particularly in respect to accuracy and stability, depends upon the degree of workmanship used in making soldered connections. Proper soldered connections are not at all difficult to make but it would be advisable to observe a few precautions. First of all before a connection is to be soldered, the connection itself should be clean and mechanically strong. Do not depend on solder alone to hold a connection together. The tip of the soldering iron should be bright, clean and free of excess solder. Use enough heat to thoroughly flow the solder smoothly into the joint. Avoid excessive use of solder and do not allow a flux flooding condition to occur which could conceivably cause a leakage path between adjacent terminals on switch assemblies and tube sockets. This is particularly important in instruments such as the VTVM, oscilloscope and generator kits. Excessive heat will also burn or damage the insulating material used in the manufacture of switch assemblies. Be sure to use only good quality rosin core radio type solder.



Courtesy of I. R. E.

HEATH COMPANY

BENTON HARBOR, MICHIGAN